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Petroleum Engineer

The Engineering Magazine of the Oil and Gas Industry

Volume 1 MIDYEAR, 1930 Number 9

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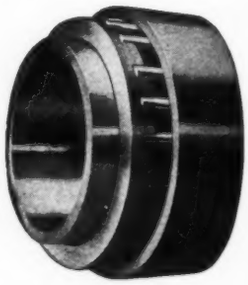

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Our First Annual Engineering Review

THE past year has witnessed noteworthy advancement in engineering practices in every branch of the petroleum industry. Drilling of straighter holes, coping with higher pressures, repressuring sands, dewaxation of lubricating oils, improvement of distillation units, more efficient laying and maintenance of pipe lines, to mention only a few major phases, have called forth the best thought and effort of engineers, superintendents and members of the entire operating fraternity. Out of their accomplishments have evolved improved methods and new equipment responsible for greater efficiency and greater economies.

Fulfilling its original purpose, The Petroleum Engineer has month by month described and interpreted these developments in successive formative stages. In this, our first Annual Engineering Review, we present, in a group of fact-filled articles, a detailed resume of the year's outstanding engineering developments in all operating branches of the industry. In accomplishing this our editors were generously assisted by many of the men most prominent in the various constructive activities. A number of these men have written articles, while yet more, whose names do not appear, supplied valuable data incorporated throughout. Thankful acknowledgment is made for their unstinted cooperation.

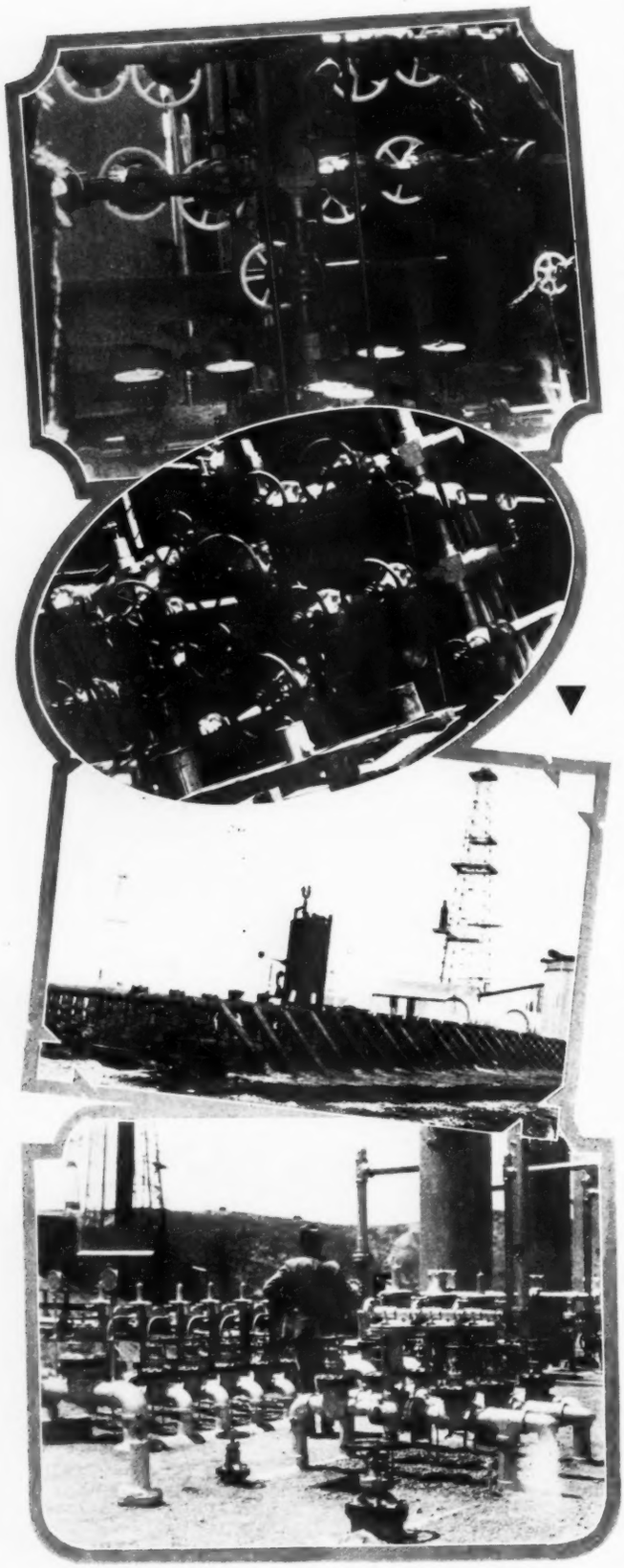
The Petroleum Engineer is published thirteen times per year—regular monthly issues appearing on the fifteenth of each month and this, the Engineering Review, on the first of June. Because of the nature of this number, features such as the Month's Highlights in Oildom, Pictorial Petroleum, Running Tour with Men in the Industry, etc., which are a part of all regular issues, have been omitted.

Upon publication of the Engineering Review—the ninth since the founding of the magazine—we feel that we have reached an important milestone with respect to our standing in the field of petroleum publications. Advertisers and readers alike have been liberal in expressing their commendation of our editorial policy and circulation plan. Pioneering in the petroleum industry, both in the publication of articles dealing exclusively with operating methods and in the use of controlled circulation, we have a natural pride in witnessing the justification of our faith in the effectiveness of each. We are exceedingly grateful to the scores of friends whose willing support has meant our success and again pledge ourselves to spare neither effort nor expense in continuing to make The Petroleum Engineer an eminently worthwhile operating man's magazine.

President

Progress in Production Methods

By K. C.



Two individual well hook-ups in the Kettleman Hills field of California, at top. Below—Two manifolds at California wells.

REVIEWING the general progress that has taken place within the last few years in oil field development and production practice, the rapid growth and introduction of new methods and equipment has been amazing. Certain factors have had a profound influence on the trend and the rapidity of the changes that have taken place. Foremost among these factors are great drilling depths and high rock pressures. These have necessitated many radical changes both in types of equipment and in methods of drilling and producing oil. Another factor has been the low crude prices that have prevailed for some time in the industry. This factor has forced producers of oil and gas to cut their operating expenses to the utmost limit. They have been impelled to delve deeply into the detailed costs of producing a barrel of oil in a frantic effort to retard fast dwindling margins of profit. If detailed cost figures and all the facts were available, quite probably it would be found that many producers of oil today are conducting a considerable part of their producing operations at a loss.

These conditions within the industry have quickened the pace of progress in oil field practice to a remarkable extent; so much so, that quite recently it brought forth the somewhat vague comment that oil now is produced too efficiently. Oil may be produced or brought to the surface too quickly so far as market demands are concerned, but manifestly it is fallacious to construe this condition to having produced oil too efficiently. While the oil industry has been in the throes of an overproduction malady, necessity, brought on by low crude prices, has resulted in radical innovations in methods and equipment which are much in advance of anything hitherto employed.

Still another factor is the location of newly discovered fields. Tidelands drilling in the Elwood field of California, for instance, has given rise to new problems of derrick foundation construction. Deep drilling in the high-pressure field on the outskirts of Oklahoma City has brought into prominence the problem of proper method of control while drilling and while bringing in a well. In the bayous of the Gulf Coastal area of the United States and in the Maracaibo Lake in South America drilling problems of still another type are encountered. Problems that arise are a result of location of the field are often somewhat local in character, such as those fields or areas—excepting Oklahoma City field—just mentioned.

Hazards are involved in deep drilling. Excessive weights on surface equipment must be minimized. High rock pressures which usually accompany deep drilling must be controlled. These involve much forethought and preparation. No longer can rule-of-thumb methods be relied upon. They have been replaced with known reliable methods based on accurate field data, tests, and engineering information.

A recent departure in the surface equipment installations at deep wells being drilled by the hydraulic rotary method in California is the use of auxiliary hoisting equipment in

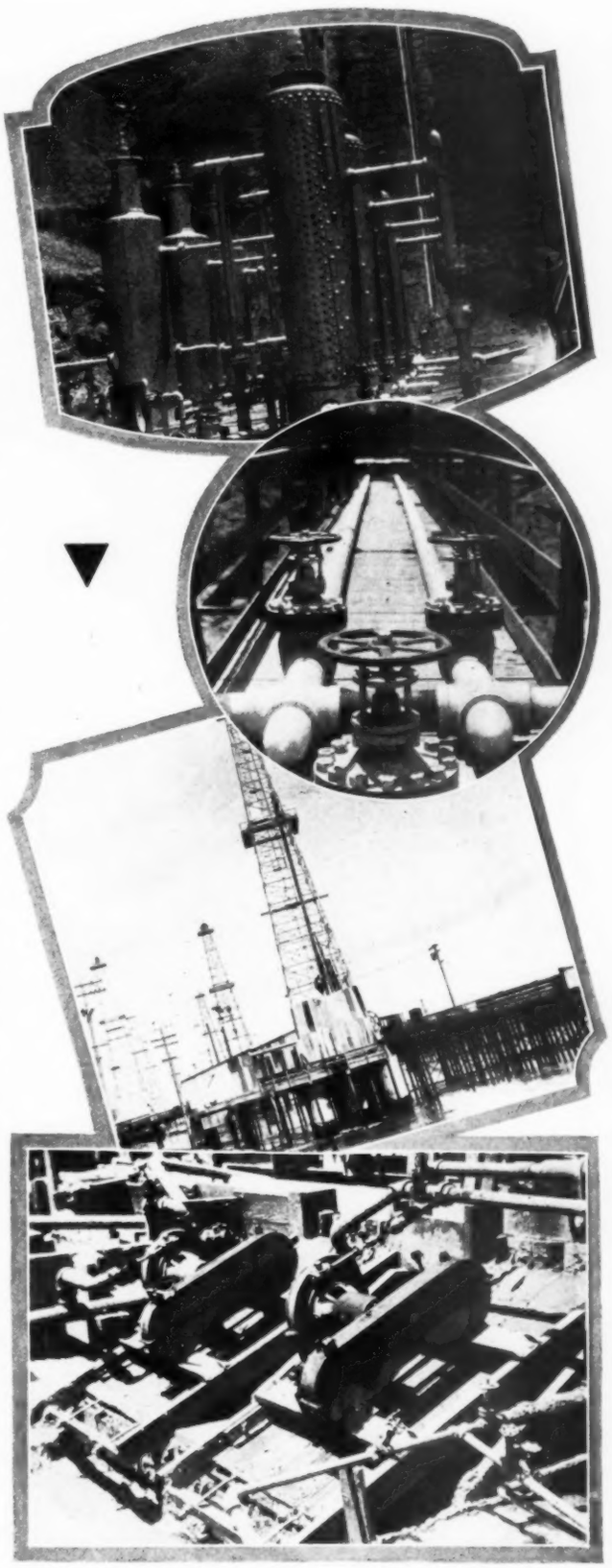
with Reference to Deep Drilling

SCLATER

place of the calf wheel. Double draw-works are used, the extra draw-works being installed on the side of derrick opposite the regular draw-works. Thus almost the last vestige of the standard cable-tool rig is about to disappear from the hydraulic rotary rig. Auxiliary hoisting equipment to replace the calf wheel as a standby may therefore come into wide use.

Great strides have been made in straight-hole drilling. Almost without exception it is accepted good practice to make—while the well is being drilled—systematic surveys of the hole for deviation from the vertical. Many operators, in addition to measuring the deviation, also determine its direction. Numerous ingenious types of instruments have been developed and are available on the market for surveying a well quickly and accurately. Progress in drilling relatively straight holes has been outstanding. The good results achieved have been hailed by the industry as a far-reaching factor in reducing both development and production costs. How this reduction in costs is obtained is well known and need not be repeated here.

More attention than ever before is being given to mud fluid, so vital a place does it occupy in deep rotary drilling in high-pressure areas. Since the inception of its use in the oil industry one of the greatest improvements in the handling of mud fluid and keeping it in condition is the introduction of vibrating screens. Within the last few months several have been put in service at deep wells in several fields. Two screens, three feet by five feet, set at an angle of 25 to 30 degrees, are used on a well. The screens are of metal and from 30 to 60 mesh, depending on the mud fluid and well conditions. So far the mesh sizes mostly used are 30 and 40. In one type screen in use the vibrations are from 1,600 to 2,000 per minute with about one-sixteenth of an inch amplitude. A one-horsepower, single or three-phase motor, or a small steam turbine, such as used for rig lighting sets, is used for vibrating the screen. One of the chief advantages already observed by the use of the vibrating screen is a big reduction in the wear and tear of the slush pumps. It is also believed to shake out an appreciable portion of the gas in gas-cut mud, although to what extent has not definitely been determined. This feature alone may be of considerable value in a field where trouble with gas-cut mud is prevalent. The use of the vibrating screen may also eliminate the necessity for large slush pits. Mud fluid can also be used for a much longer period without "wearing out" or losing its desirable physical and colloidal properties. Among the chief advantages claimed for the use of a vibrating mud screen are: saving in addition of new mud; increased efficiency of properties of mud in circulation; saving in pump parts; saving in wear of casing, drill pipe and swivel connections; faster drilling, which results from the instantaneous removal of drill cuttings and absence of delays; accurate samples of drill cuttings always easily obtainable, and more efficient operation of slush pumps.



Top—Two-stage separation on a California lease. Next to top—A pair of lead lines. Next to bottom—Drilling in the ocean at Elwood Terrace. Bottom—Vibrating screen for mud fluid.

In some fields, the disposal of the "worn-out" mud fluid is quite a problem and necessitates the preparation of large sumps or ponds for its disposal. Central plants equipped with classifiers and other equipment for reconditioning the mud are under process of installation in the Ventura Avenue field, California. In this field, deep drilling, topographical conditions, the development of a large amount of acreage held in large blocks and an orderly drilling program all favor the installation of such central plants. All new mud-fluid is mixed at a plant high up on the hillside, where the clay is dug from the mountain side with suitable equipment. After thorough mixing, the mud-fluid is conveyed through a six-inch line to the reconditioning plant whence it is distributed to the drilling wells. Each well has a 500-barrel tank full of good mud-fluid in case of emergency. When the mud becomes "worn out" it is returned through a system of wooden flumes to the reconditioning plant. Large savings are expected to result from having the mud reconditioned at a central plant, also the hazards of blow-outs because of poor mud should be almost eliminated.

Flow lines on a Belvridge field well in California.

Equipment for maintaining proper control of bit pressure is now in general use. Since weight indicators and other types of equipment have been adopted for controlling the weight on the bit there has been a marked decrease in the number and frequency of drill pipe twist-offs. In order to make an intelligent study of the cause of drill pipe failures, it is necessary to know the character and variation of the tortional stresses to which the drill pipe is subjected in actual field service. Indicators and methods which will yield reliable information of this nature are now being developed and should prove a valuable adjunct in overcoming twist-off troubles.

A recent development of importance is the use of taller derricks. These are being tried out in California—the Mid-Continent and—the Texas fields.

Steam raising equipment has undergone vast changes in the last two years. Boilers of 300 pounds per square inch working steam pressure are now in use. Condensing equipment together with superheaters for field use are now claiming the attention of engineers. Methods to cut down condensation losses, boiler troubles, and to determine more efficient methods of using steam in the field are being sought. In the Gulf Coast area tests are underway with evaporation and condenser equipment to determine the feasibility of using brackish water for steam raising purposes where drilling operations are carried on in brackish water lakes.

In Inglewood field, California, a test with Diesel engines driving direct current generators which supply power to a drilling well is in progress. Two 200-H. P., 6-cylinder, 4-cycle, full Diesel engines are connected with V-belt drive to two 225-K. W. direct current generators, which are wired through a switching panel to a 250-H. P. direct current motor, directly connected to a reduction gear which is in turn connected by chain to the draw-works, and a 125-H. P. direct current motor connected to a 6 by 16-inch power-driven slush pump and to recording and indicating meters.

Casing practice has advanced rapidly with deep drilling requirements. Landing heavy strings of casing at depths between 8,000 and 9,000 feet by the use of float valves and float plugs is now done with the ease and facility of landing a 2,000-foot string. Developments in casing practice are so varied and wide in scope that they will not be touched on in this brief review, but will be discussed in articles appearing at a later date.

Production methods and equipment are undergoing a gradual change to meet deep well conditions. Some recent interesting innovations have also been tried which are worthy of mention at this time.

Curtailment of production to pro-ration requirements has brought into prominence the importance of pressure control of wells. In areas of large flush production and high pressure it is becoming general practice to equip the deep wells with heavy Christmas tree connections so arranged that they provide maximum flexibility of control and are of ample strength to meet all contingencies.

A standard method of controlling a flowing well is by the use of flow beans or choke nipples. In some cases a flow bean is used at the lower end of the tubing in the well, with another bean at the surface for making auxiliary adjustments. High rock pressures with correspondingly high back pressures at the well casinghead have brought about changes in methods of gas separation at the well. Multiple gas trapping or separating systems have come into use. Probably the greatest development in this connection is in the Kettleman Hills field, California. The gas and oil as it comes from the well is subjected to two-stage separation. Each stage may have two or more traps, depending on the size of the well, so that the traps or separators are connected in multiple series. Traps of about 750 pounds per square inch working pressure are used for the high-stage and traps of about 100-pound pressure for the low stage separation. Elaborate, but none the less necessary, manifold systems have been designed for handling the gas. A problem that confronts the oil producer in high-pressure large flush producing fields where no direct outlet for the large volumes of gas produced with the oil exists, especially if the gas from the high-pressure traps is dry, is the proper utilization of the energy that the gas has by virtue of its high pressure. There is a dissipation of large quantities of energy in reducing the gas to atmospheric pressure unless some outlet for making it do useful work is found. In a field where there are wells pumping or producing by gas lift, or where repressuring operations are carried on, an outlet for a major part of this energy can usually be worked out.

Improved Methods for Manufacturing » » Automobile Lubricants

By
H. C. MOUGEY[1]

MANY of the oil companies have improved their methods of manufacture of oils, and much work has been done in laboratories on the use of oils, but insofar as the general public is concerned, there has been little change in the subject of lubrication of automobiles during the last year. The principal difficulties which we have with engine lubrication are:

1. Cranking the engines in cold weather.
2. Establishing a flow of the lubricant in cold weather.
3. Excessive oil consumption at very high speeds.

In the summer time, the problem in factor 3, the high oil consumption at high speed, is not insurmountable, since this trouble can be overcome by using oils of high viscosity and these high viscosity oils in the summer do not cause trouble on cranking the engines or on establishing lubrication as soon as the engine starts. However, in the winter time we do have considerable trouble due to the facts that in order to secure easy starting in cold weather an oil of low viscosity must be used, and in order to establish lubrication as soon as the engine is started, oils that are both low in viscosity and low in pour test must be used. If cars with such low viscosity oils are driven for long periods of time at high speed the oil consumption will be very high.

Hot oil pumps for a cracking unit.

Until several years ago it was generally believed that lubrication trouble could be overcome by changing from an oil of one trade name to oil of another trade name, but within the last few years the facts have become well established concerning the necessity for the proper viscosity and pour test to meet the above difficulties.

Several years ago most of the automobile companies discontinued the practice of recommending oils by trade names and adopted the S. A. E. viscosity numbers. The oil companies in general adopted the S. A. E. viscosity numbers and either put such numbers on their containers or notified their men at the filling stations which of their particular trade-marked oils correspond to the S. A. E. viscosity numbers. This system has been in use for several years, but it has not solved the problem on account of the lack of interest in the entire subject, both on the part of the automobile driving public and on the part of the filling station attendants. This necessity for the use of oils of proper viscosity and the possibility of obtaining them throughout the country by the use of S. A. E. viscosity numbers requires additional publicity, and it appears that this can be accomplished only over a period of years.

The subject of transmission and rear axle lubricants is one which is in a very much worse condition than that of crankcase lubricants, since there is no recognized method of classifying lubricants for transmissions or rear axles. The American Society for Testing Materials and the Society of Automotive Engineers both have committees working on this subject, but progress is very slow.

There are two schools of thought on the subject of transmission and rear axle lubricants. Those in favor of the ordinary mineral oils argue somewhat as follows: Automobiles are distributed and operated over the entire world. For this reason they must be able to operate with a reasonable degree of satisfaction on the lubricants that are sold locally. If an automobile should require a special lubricant and should be unsatisfactory with the ordinary material that can be obtained locally, such an automobile would be in continual trouble. The problem of the automobile engineer is to make his product so that it will operate with reasonable satisfaction using lubricants obtained from a wide variety of crudes and any change in design which makes a lubricant of special properties necessary means that the car is bound to be unsatisfactory in the large number of cases where this special lubricant is not obtainable. In addition, if the car is satisfactory with the ordinary lubricants it is a waste of money to buy special lubricants at a fancy price for the car.

Those in favor of special transmission and rear axle lubricants contend that the lubricants should be considered as much a part of the car as the steel, bronze, or other materials. If certain additions to a lubricant should make it superior in its properties, the oil industry should be able to manufacture and distribute such lubricants, and in addition such lubricants should be marked so that the individual car owner could distinguish between the ordinary lubricants and the special ones.

[1] General Motors Corp.

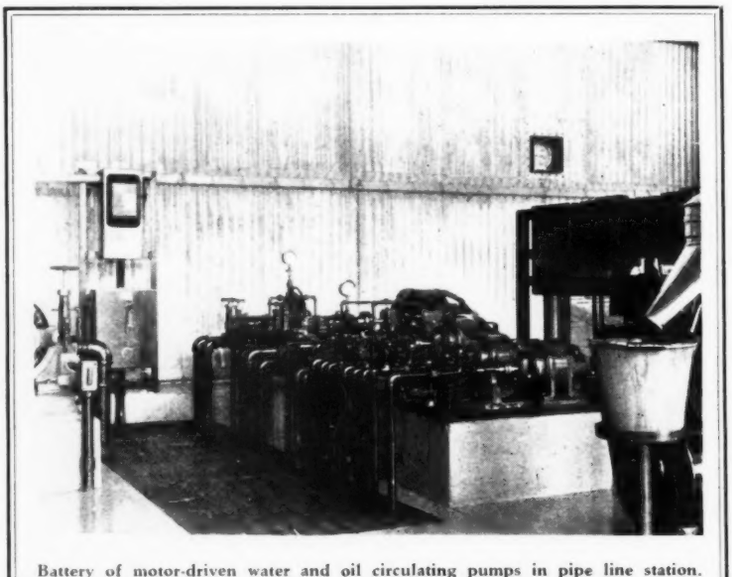
Major Factors in Building Diesel Pipe Line Stations

By R. G. LEWIS, *Master Mechanic, Prairie Pipe Line Co.*

REACHING a decision as to the proper selection of equipment for building a pipe line station to handle a predetermined volume of oil at a given pressure entails careful consideration of a great many factors. The analyzing and reducing of the problem to a point where one of four types of driving power, oil engines, gas engines, steam engines or electric motors, will be selected to drive either reciprocating or centrifugal pumps, is a big problem in itself and might be considered the most important from an economical standpoint.

It is not the intention of this article to attempt to deal with the selection of the various types of prime movers and pumps, but rather to discuss some of the salient features of one particular hypothetical case.

Assuming that a pump station is to be built where the conditions call for oil engine-driven reciprocating pump units for a daily capacity of 100,000 barrels against a line pressure of 750 pounds, the first problem to consider would be deciding upon the number and size of units to handle this amount of oil.



Battery of motor-driven water and oil circulating pumps in pipe line station.

Such a volume of oil could be handled with one, two, three or any number of units, but good engineering practice obviously rules against the installation of a single 100,000-barrel unit. Assuming that a spare or idle unit would be needed, the plan for two 50,000-barrel capacity units likewise is eliminated from consideration because of the necessity of a spare or idle 50,000-barrel unit at all times. If there was a probability of a substantial increase to the station's capacity in the near future, the selection of 50,000-barrel units might be wise.

Three or four units may be the proper selection, but five or more units would obviously be too small for good economy and especially so where there is a possibility of the station capacity being increased. The more units installed would, of course, cut down the size of the spare unit, while, on the other hand, the fewer number of units put in would lead to better operating efficiencies.

Three 35,000-barrel units would be an economical size and the fourth 35,000-barrel spare unit would not be too large for consideration. The selection of this size unit would be desirable from an operating standpoint as well as from the standpoint of future increases in station capacity.

Four 25,000-barrel units with the fifth as a spare would be a greater number of units than absolutely necessary and would lead to more piping and connections and more detailed work of supervision. Maintenance costs would also be higher for the greater number of units. For the reasons briefly outlined it is concluded that the three 35,000-barrel units with a fourth as a spare will be a good selection for

General view of brick station building with

the purpose of this problem. A 35,000-barrel pump is selected rather than the 33,333-barrel pump because it will give a margin for slip and will take care of any small and varying conditions which always arise. Should it be desired to put the capacity down to the 33,333 barrels, this margin can very easily be reduced by lessening the engine speed. The type of pump to handle this capacity is the next consideration.

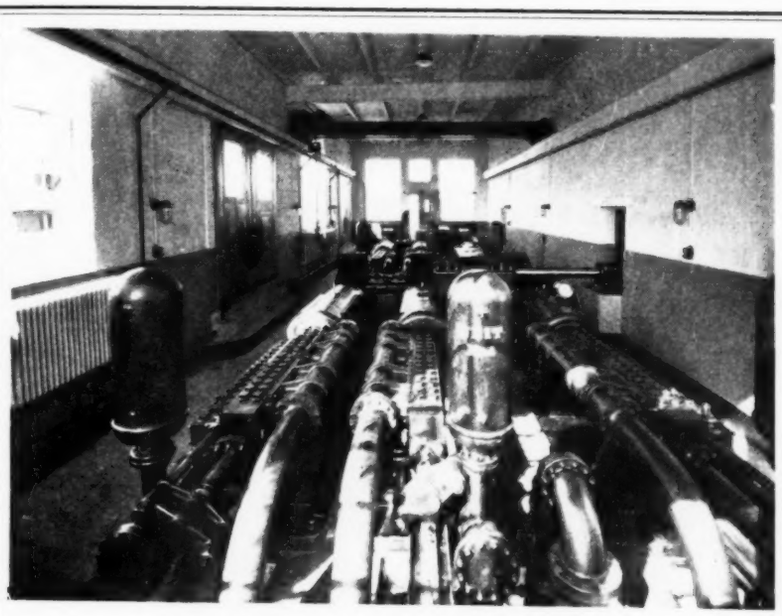
There are two main types of pumps that would be applicable to this capacity. These are the 6 by 36 horizontal triplex and the 6 or 6½ by 24 horizontal triplex. The 6 by 24 pump would have to be run at 60 revolutions per minute and the 6½ by 24 would have to be run at 55 revolutions per minute for this capacity. These speeds are a trifle high to give the best efficiency on account of the greater number of reversals required, and the poorer valve action.

The 6 by 36 pump would give the desired capacity at about 40 revolutions per minute. This speed is more in line with the speeds recommended by the pump manufacturers and, due to the longer stroke, will give better mechanical efficiencies, better suction and consequently better valve conditions, as well as longer life. Therefore, this type pump will be selected.

The next selection is the size of the engine necessary for this unit. The hydraulic horsepower needed to pump 33,333 barrels of oil per day at 750 pounds pressure is about 400 horsepower. Dividing this by between 85 per cent and 90 per cent, the pump's mechanical efficiency, we have about 450 brake horsepower. Adding about 50 horsepower, with which we must drive a generator, we have 500 brake horsepower. It is desirable to operate the engine at from 75 to 85 per cent of its full load capacity because such operation insures better over-all efficiencies and longer life for the engine. This will indicate the selection of a 600-horsepower engine.

We now have four 35,000-barrel pumps driven by 600-horsepower engines, one unit to be held as spare, with which to pump 100,000 barrels of oil per day at 750 pounds pressure.

It has been assumed from the start that a spare unit is to be used. This assumption may be open to argument, however; the problem is to pump 100,000 barrels of oil per day and, in line with every-day main line operation, this oil is to be pumped day in and day out. Since the cost of an additional unit for spare would be slightly less than 10 per cent of the cost of the two eight-inch lines or their equivalent, which one unit is serving such an investment appears to be mighty good insurance of maintaining 100 per cent capacity, the revenue therefrom, and the good will of the customer who is being served. The spare unit, moreover, gives the operator the opportunity of overhauling and adjusting his engines when the necessity arrives, and this factor is considerable in view of the life of the engine.



Partial view of pump room side of station.

The auxiliary equipment for a station of this size will of course include a low-pressure pump for drawing the oil out of the line by suction (in case of a break), air compressors, water pumps for the engine cooling systems, lighting for both the station and the cottages for station employes, pumps for both fuel oil and lubricating oil, and such minor equipment as fire pumps, ice machines, etc. In addition to the above, there will be the power generating units for furnishing power for the above equipment, which will consist of the main generators driven by the main oil engines and an auxiliary unit for use when the main engines are shut down because of a line break or some other accident.

recent addition and general view of grounds.

As the modern method of driving such units is by individual motors rather than by complicated line shafting and pulley and belt drive, it is assumed that all such equipment in this station is to be motor-driven. In this case a 30 KW generator driven by an auxiliary oil engine is indicated. We believe it is good practice to get for this purpose one of the many direct-connected oil engine generator units now on the market. In addition to this unit it is also good practice to install two 30 KW generators to be driven by two of the main oil engine units. It must be remembered in this connection that these latter generators must be so designed that they will give constant voltage over the varying operating speeds at which you may operate the engines. These latter generators will be used in preference to the auxiliary engine and generator whenever it is possible, or rather the auxiliary engine and generator are to be used only in case of line break or some other emergency of this nature. In an article of this nature it will of course be superfluous to go into the description of the type, size and details of each of the pumps, motors, air compressors, etc., that will be necessary to the installation. For our present purposes let it be assumed that all of this material has been properly selected and installed.

Water-treating tank.

In considering a building for this station, the life of which will be indefinite, a brick or cement block building with corrugated asbestos covered roof is selected. The trusses and framework of the building will of course be steel. The allowance of liberal clearance around all machinery, good allowance for window space for natural lighting, allowance for ventilation and all similar problems which are bound to come up, should be kept in mind in designing the size of the building. It is well to design the building with a firewall between all of the main oil engines and the oil pumps, as it has been well proven in the past that such an installation pays well in the diminished fire hazard.

In the past, practice has been to cover up all piping and make it about as inaccessible as possible. This applies especially to heat exchangers, drain barrels, sump pumps and similar equipment. Modern practice is bringing in the use of so many of these small units, such as filters, lubricating oil apparatus and kindred equipment, that it is now becoming desirable that they be placed in a position where they will be accessible for repairs, cleaning and extensions. Therefore, the design of this building will include conduits large enough for ample head room and giving wall space where all the piping may be arranged in such a manner that each line will be accessible without disturbing any of the others. This calls for a basement to be designed to accommodate the above-mentioned apparatus. Such construction is about as easily accomplished as it would be to fill back the excavation between foundations and the side walls of the building. Without the large conduits and basement, arrangements must be made for complicated piping in small, restricted and inaccessible conduits. Ventilation of these conduits must be taken into consideration, but this item is easily accomplished. In one case this was accomplished by using the air pressure generated by the flywheel of the main oil engines. This design, using large conduits and a basement, keeps the station free of cluttered-up piping and also keeps the building well drained and allows of compact but accessible design.

In the earlier oil engine plants the oil vapors and smoke escaping from the open crank cases of the engines made ventilating a difficult problem. In this connection several clever devices were developed to prevent these gases escaping into the room. Today, however, oil engines are built with closed crank cases and all connections where gases are liable to escape are well protected against such a condition. This has made the problem of ventilation comparatively simple and it may be accomplished with the installation of the usual ventilators in the roof of the building, both over the engines and the discharge pump rooms. A ventilating fan or two might be installed at convenient points for use in extremely hot weather, especially in the conduits, but these are not absolutely necessary.

Another problem to be considered is that of heating the building during cold weather, and also supplying heat for the fuel oil system, which will be discussed later. The size of the heating plant will of course depend on the location of the plant and the climate. Assume that the plant will be built in Oklahoma and that climatic conditions are those which are found here. The heating system will be steam heating with a familiar type of steam coil and directional blower heater. This system, when properly adapted, gives very efficient heating because of the fact that the heat is supplied to the point where it is needed. Although the heating will be needed for only three months, or possibly four months at the most, during the year, a system must be designed which will take care of the most extreme weather which will probably be experienced. For this purpose a low-pressure steam boiler of approximately 80 boiler horsepower rating is needed. This boiler will be set in a separate house a short distance away from the main engine and pump building, which will also house the boiler feed pump, all boiler equipment, and fuel oil separator.

In addition to the steam necessary for heating the building, steam and hot water will be needed for heating fuel oil and lubricating oil for clarifying purposes, and for heating fuel oil so that its viscosity may be brought down to the point where it may be handled easily during cold weather. Some hot water and steam will be needed, even in hot weather, and in order to supply this without running the boiler the year round, water jackets of sufficient size will be put on the exhaust lines of the oil engines. These water jackets will supply the hot water needed for the above-mentioned fuel and lubricating oil clarifying in hot weather or whenever it is not necessary to operate the boiler.

In some cases it might prove economical to install exhaust

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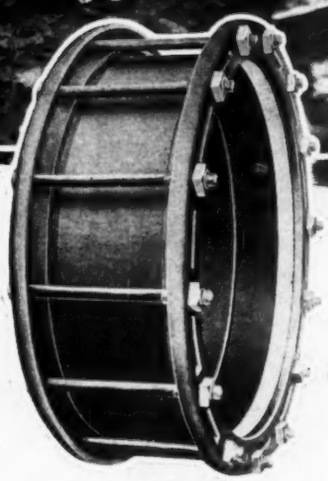

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gas fire tube boilers, which prove very economical and will supply considerable heat. However, in the station which is under consideration this type heating system will not furnish enough heat for the more severe conditions and, as long as a regular boiler installation is considered necessary, the plain exhaust line water jackets will prove more economical than the exhaust gas boiler.

As mentioned above, some heat will be necessary for fuel oil and lube oil clarification. This clarification will be accomplished with the usual type centrifuge. All fuel oil will be first heated, then run through the centrifuge. It will also be stored in tanks containing heating coils, which will lower the viscosity in cold weather to the point where it may be run easily. The lubricating oil will also be heated and run through a separator, but will then be run through a cooler to bring it back to a temperature at which it may be applied to the machinery. This heating and cooling of the oils will be accomplished with heat exchangers of conventional design. This arrangement of storing, clarifying and handling both the lube oil and fuel oil with the equipment and design required is a separate subject in itself. We shall go no farther into this subject in this article than to mention, as above, that the oils will be clarified with proper equipment.

Six hundred h. p. unit in station with enclosed flywheel and guards for moving parts and belt driving generator. The rail-guarded opening in floor is entrance to cellar and lube oil clarifier is at right, with sump pump to the right of it.

Another consideration in the design of such a station as this is the water system for cooling the engines. A Diesel oil engine requires about 10 gallons of water per horsepower per hour for cooling. With three 600-horsepower engines this means we will have to circulate and cool about 18,000 gallons of water per hour, which is a sizable consideration. The type of cooling system depends on the quality of the water; that is, whether or not it is very hard and contains quantities of scale-forming salts, or if it is fairly soft with very little scale-forming solids. Where the latter is the case a reservoir system, consisting of a large, open concrete reservoir from which the water is pumped either directly over the engines or, better, to an overhead tank from which it runs by gravity over the engines and is then pumped back to the reservoir, would prove to be the most economical. This system may also be used, when the water contains an appreciable amount of scale-forming salts, by treating with suitable chemicals to remove the salts. In this connection it will be necessary to install treating tanks of sufficient size to treat enough raw water to offset the daily losses due to evaporation and seepage. It is also desirable, where the treatment amounts to any considerable figure, to install filters to remove the precipitate, which, if allowed to carry over into the reservoir and thus into the engine jackets, will build up scale of itself.

Where good water is scarce or the water available is very hard, the most economical system is what is known as the closed system. There are several types of closed systems and there is now under way considerable development along this line. One of the most worthy of these is the cooling of the engine jacket water with heat exchangers, making use of the oil which is being pumped into the station as the cooling medium. In this case the cooling water is of course carefully treated to remove all injurious salts and is then put in the system. This water as it is being used is then pumped through a heat exchanger, through which is also directed the discharged oil from the main pumps. In this way a double purpose is accomplished—namely, that of cooling the water and that of heating the oil. The latter effect—that of heating the oil—decreases its viscosity slightly, and consequently decreases the power necessary for pumping very slightly. This effect is, however, small and barely worthy of consideration, except in the case of certain types of oil of which the viscosity increases very rapidly with slight drops in temperature.

Another closed system worthy of note is that where the cooling water is passed through a heat exchanger of which the cooling medium is raw water. In this case the raw water is cooled in a cooling tower and the exchanger is so arranged that its tubes may be easily cleaned of scale. In one type of heat exchanger used for this purpose, advantage is taken of the expansion and contraction of the tubes due to variances in temperature by making them self-scaling.

It is also worthy of note that in the past it has been the practice to install a water pump to the pinion shaft of the main discharge oil pump for circulating cooling water over the engine. This practice is being discarded and in its place the installation of a separate motor-driven centrifugal water pump for this purpose is being used.

There are a few other items that should be mentioned in an article of this nature. Suitable fire extinguishing equipment should be supplied. It is considered advisable to install a fire pump in this connection as well as the customary fire extinguishers for both the main plant and the cottages of its attendants.

A small ice plant should also be installed. This does not need to be elaborate and a machine of sufficient size may be installed in the tool house or some other convenient place around the station.

In laying out a station of this kind the design must be made with the possibility of future extensions in mind. Many stations are now in existence which stand witness to the fact that no such provision was made. This is shown by the fact that so many of them are all cut up by one addition after another. The simplest, cheapest and most satisfactory time for planning future additions is when the station is first designed. This point cannot be emphasized too strongly.

The Care *and* Treatment *of* Cable Tool Bits

By FERD J. SPANG

While this article by Mr. Spang is somewhat longer than our usual article, the wealth of information it contains can be utilized to correct the evils now prevalent in the care of cable tool bits. We consider this article one of the most important contributions to contemporary petroleum literature, and are extremely grateful to Mr. Spang for his permission to publish it.—Editor.

DIFFICULTIES encountered in the standard cable tool method of drilling arise from varied reasons. If one were to list those which lead both directly and indirectly to the most loss in this industry, he would undoubtedly place the cable tool bit at the head of such list. After placing it there he would, upon analysis of its contributions, find that the cutting or lower end causes the most trouble.

Just why the cable tool operator, as well as the manufacturer of drilling tools, should leave this problem to find its own solution is rather difficult to explain. Improper dressing and hardening of bits add considerable to the cost and delay of cable tool drilling. It is a problem, and a serious one, that should have the co-operative study and support of every man engaged in the industry, from the tool dresser up to and including the owner.

Because of improper heating, poor dressing and abuse in hardening, bits spawl, break and batter, and with continued handling of this kind soon lose all semblance to a proper tool for rapidly drilling a round and straight hole. (See Figure 1.) Broken pieces left in the hole to be drilled up retard the drilling and add materially to the crookedness of the hole. Needless to say, this all wastes bit steel, adds to the work of the crew and is the direct cause of many jumped pins and other tool breakage. It would be hard to estimate the cost of the excess wear on tools, particularly joint collars, etc., on the excess wear of wire lines as well as on the inside of casing, caused by crooked holes drilled with improperly handled bits. The size of such losses fade almost into obliteration, however,

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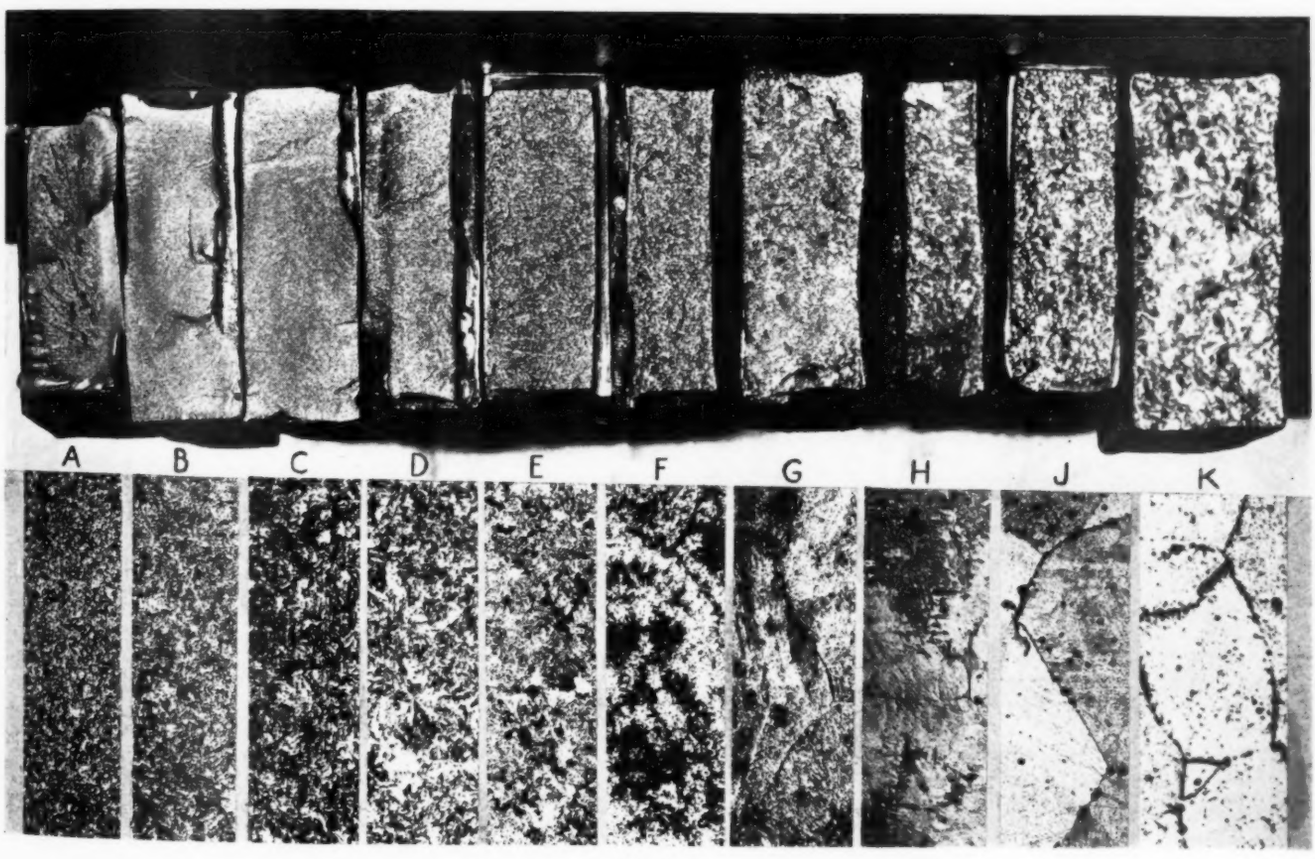

Fig. 2.

The above illustrates the change that takes place in the grain structure of steel as a result of heat. The upper row shows natural fractures, the lower shows the corresponding piece magnified. The pair to the extreme left shows the result of heating to the proper hardening temperature and then cooling. Each succeeding pair show the result of a slightly higher temperature; those to the extreme left show the result of a burning oxidizing temperature.

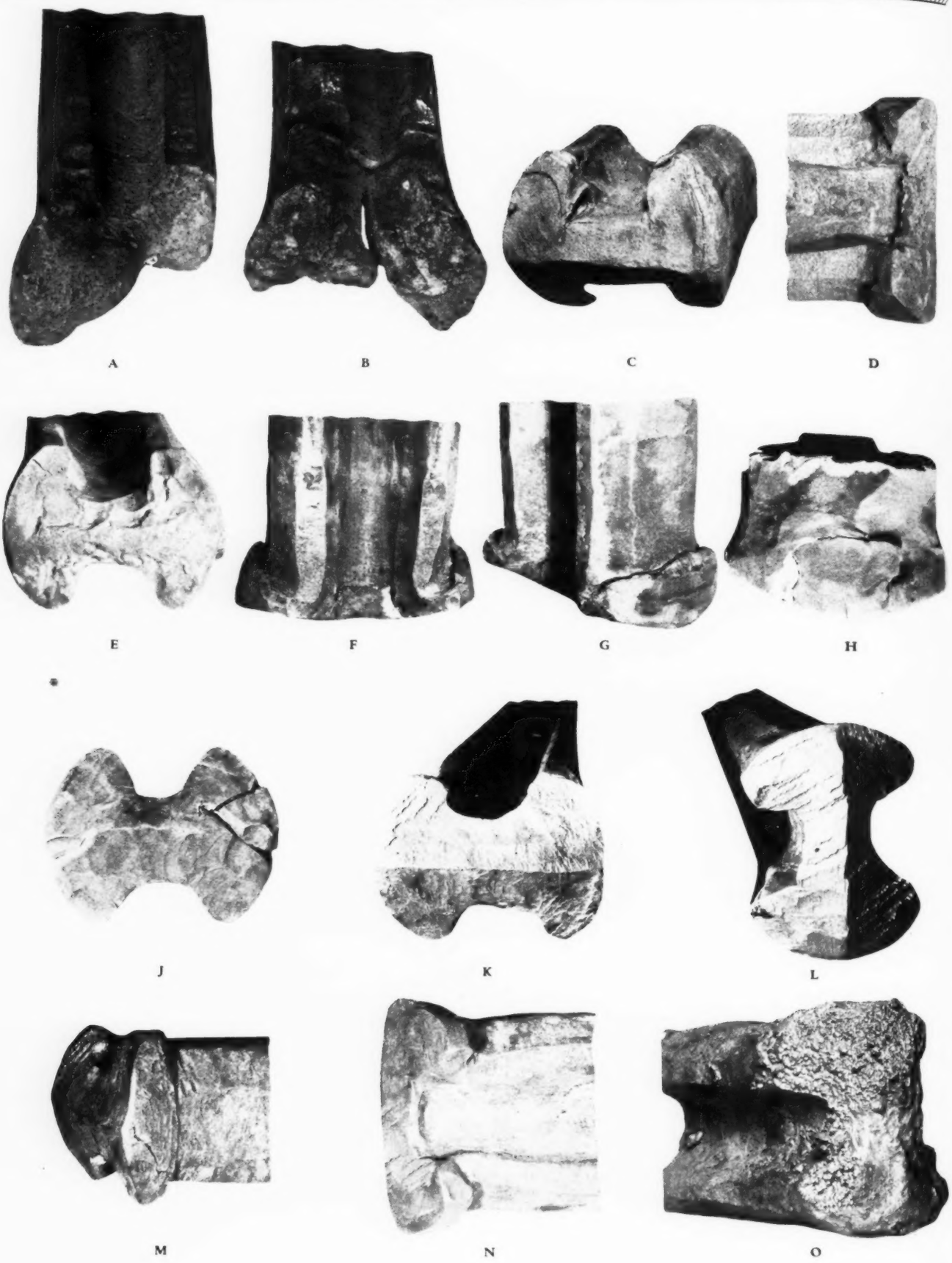

Fig. 1.

The above illustrations, the product of different manufacturers and fields, show a few of the many results of improperly handled bits. Many worse examples could easily be secured. Such conditions can be avoided with correct, careful handling. All of these were checked for soundness and chemical composition and found to be well within properly defined standards.

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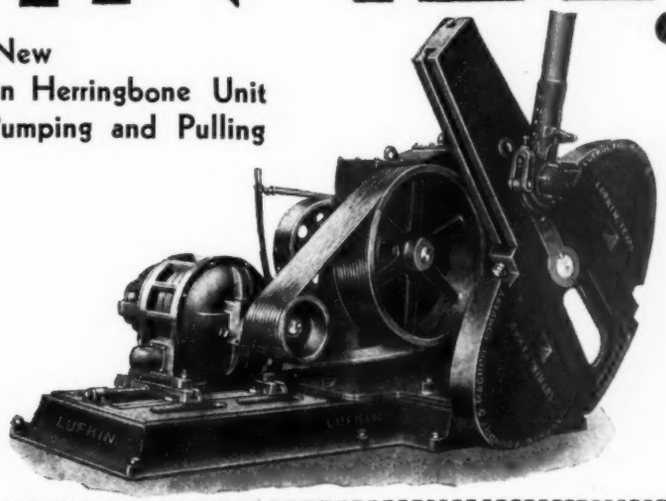

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Fig. 3.

Fig. 3 illustrates the important points to be considered in building a forge. The baffle wall is designed to split the flame and spread it downward and outward so that it burns up the side walls.

Fig. 4. Decarbonized steel will not harden; the light area on the lower part of the illustration shows the absence of carbon at the steel's surface caused by an oxidizing flame at high temperature. The dark area at the extreme top or inside of the steel is normal for bit steel. (Magnified)

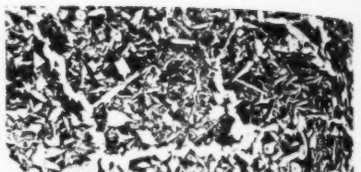


Fig. 4.

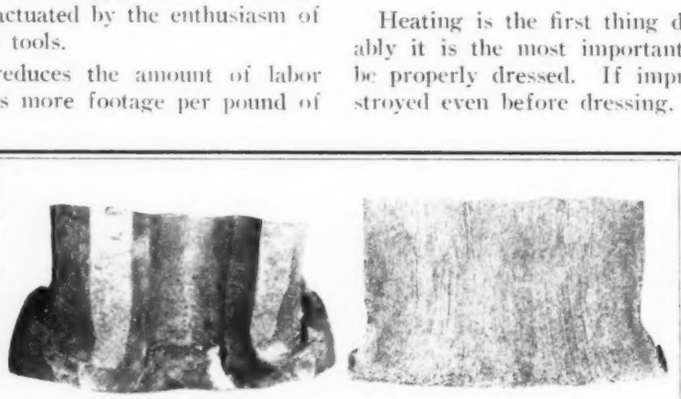
when compared with the enormous losses through casing jobs arising directly from this unnecessary condition. Excessive wear on pumping equipment in subsequent operation may also be added to the toll of this waste.

Given a good set of bits, a properly designed forge and a fair understanding of steel, the regular crew can, without undue effort, reduce these losses to the minimum. The main requirement seems to be the distribution of a knowledge of steel; that is, what steel really is and what it does as the result of certain heating, working and cooling. To this should be added the desire to apply such knowledge which, of necessity, must be actuated by the enthusiasm of the manager or owner of the tools.

Correct handling of bits reduces the amount of labor performed by the crew, makes more footage per pound of steel used and per unit of time, and insures a rounder, straighter hole, resulting in less wear and tear on the whole equipment and also reduces the chance of "run" and "pull" casing jobs, all of which will tend toward a lowering of production costs and thereby make the position of the operator and his employes more secure.

Properly made bit steel is a homogeneous composition of iron, carbon, silicon and manganese in correct proportions. Its composition and method of manufacture is the successful result of years of study and experience by some of our most able steelmakers. In its ideal hardened condition, bit steel is both hard and tough, is fine of grain and should not batter nor break easily, but should wear slowly away. When heated it makes three very important changes, which are expansion, softening and grain growth (see Figure 2), together with other changes of less importance. When cooled it makes but two important changes, these being contraction and hardening (or toughening or annealing). The volume of the grain unit does not materially change in cooling, except a possible shape rearrangement which is the result of the rate and method of cooling and affects the hardness. On these changes is based the treating, the care or the abuse of bits.

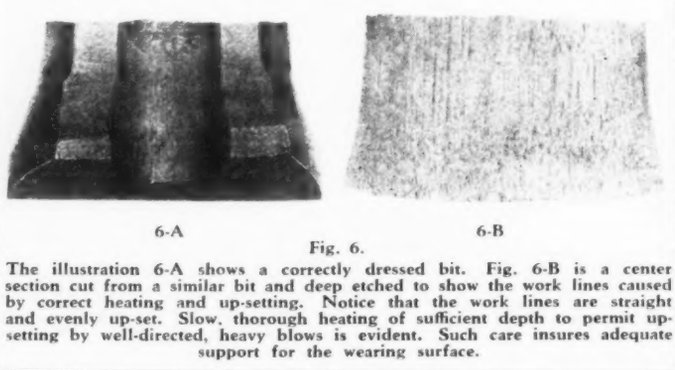
Heating is the first thing done to a bit and unquestionably it is the most important. If properly heated it can be properly dressed. If improperly heated it may be destroyed even before dressing.



5-A 5-B

Fig. 5.

The illustration, Fig. 5-A, shows the lapped over wearing surface of a bit caused by quick and shallow or short heating and light sledge or ram blows. Just above the wearing surface the bit is oxidized under size from using a thin fuel mixture. The illustration Fig. 5-B is a center section cut from a similar bit and deep etched to show the work lines caused by such treatment.



6-A 6-B

Fig. 6.

The illustration 6-A shows a correctly dressed bit. Fig. 6-B is a center section cut from a similar bit and deep etched to show the work lines caused by correct heating and up-setting. Notice that the work lines are straight and evenly up-set. Slow, thorough heating of sufficient depth to permit upsetting by well-directed, heavy blows is evident. Such care insures adequate support for the wearing surface.

The important thing to start with is a proper forge. It should be so constructed as to allow for complete combustion of the fuel mixture away from the bit and at the same time have the heat evenly distributed around it. It should also be long enough to allow sufficient of the bit to get hot to permit complete stoving or bucking up to back up the wearing surfaces. For a suggested forge see Figure 3.

The arrangement and direction of entrance of the mixer as well as the baffle wall is important, but even more so is the composition and completeness of the mixture of fuel and air. A surplus of air or a portion of unmixed air will do more or less damage to the steel,

depending upon the final temperatures, the time the heat is retained in the furnace and the amount of the excess air. Under no circumstances should the blast strike or come into combustion on any part of the bit. The determining factor in the hardness and usefulness of the bit steel is carbon, together with its proper minute distribution. Carbon is attracted to and readily joins with oxygen, the attraction becoming greater at higher temperatures. Therefore, any surplus air, which contains oxygen, in a hot furnace becomes a decarbonizing agent which draws from the surface of the hot steel considerable of the carbon, and the steel becomes decarbonized and cannot be hardened. (See Figure 4.) For this reason it is essential that only as much air be introduced with the fuel as will be completely consumed by it. A small surplus of fuel in the mixture, although it may slightly retard the rate of heating, does no particular harm to the hot steel, but does insure complete consumption of the oxygen. It is also a great aid in preventing steel from being burned, as it is seldom that steel is burned by a mixture which is rich in fuel.

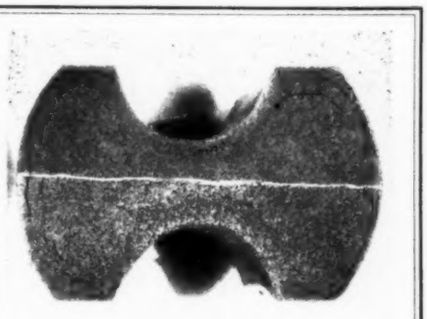


Fig. 8.
Thin mixtures go into incandescent combustion on sharp corners. Such points quickly become excessively hot and as there is no other heat of consequence on the balance of the bit, the inequality causes ruptures or shells.

Another thing about an oxidizing or thin mixture is that it oxidizes or forms heavy scale on the steel. This excessively reduces the size of the blade, and it of necessity requires more of an upset to get it dressed out to gauge. Such a condition leaves the wearing surface with a weakened support and is therefore partially responsible for breakage. Because of the smallness of the blade the wearing surface is shorter than need be, resulting in the bit wearing quickly out of gauge. (See Figures 5A and 5B.)

A proper heating mixture is one that will burn with some flame color at the openings of the forge. This color should be light orange and may produce a slight amount of smoke and odor. The combustion should not be completely transparent.

The rate of heating and the final temperature are very important items to be considered. The colder steel is, the more brittle it is, and the slower it conducts heat from the surface to the interior; hence, for these two combined reasons the initial rate of heating should be very slow and the mixture rich to eliminate cracks or ruptures in the bit. Quick heating of the surface of the steel expands and lengthens it and tends to pull it away from the center, in this way causing a rupture. (See Figure 7.)

A thin mixture goes into combustion only when it strikes some object. If this object be the bit, it tends to combust on the sharp projections of the corners of the bit, heating them much quicker than the body of the bit, causing them to shell off or break off, or at least to start cracks. (See Figure 8.) These cracks may not be visible until quenching, or possibly not until further use of the bit, but there can be no doubt of their presence.

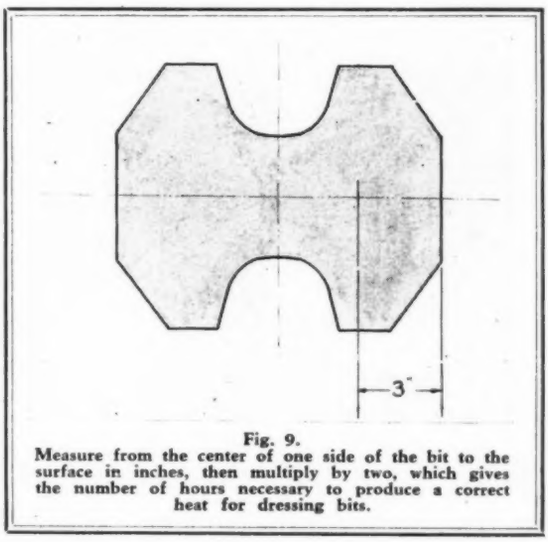


Fig. 9.
Measure from the center of one side of the bit to the surface in inches, then multiply by two, which gives the number of hours necessary to produce a correct heat for dressing bits.

After a short period of preheating in a rich mixture the blast may be thinned and increased and the bit consequently heated faster. In the forging and working of steel in steel mills and forge shops it has long been the practice not to heat steel such as bits are made of, at a rate including the pre-heat period, faster than one-half inch per hour when measured from the center of the greatest section to its nearest surface. By this rule a bit (twenty-inch), as shown in Figure 9, would measure three inches (3″) to the center of the mass from its nearest surface, and hence require six hours for a proper heat. Heating time for larger or smaller bits can be computed in this manner. The need of this practice seems to be neither fully realized nor followed in the oil country; as a result, in order to get the bit soft enough to work at all the surface is excessively overheated while the interior is very much underheated; consequently, only the surface moves when struck with the ram or sledge. This causes the soft surface to slip over the harder core and wash out over it (spread) to get sufficient wearing surface. The

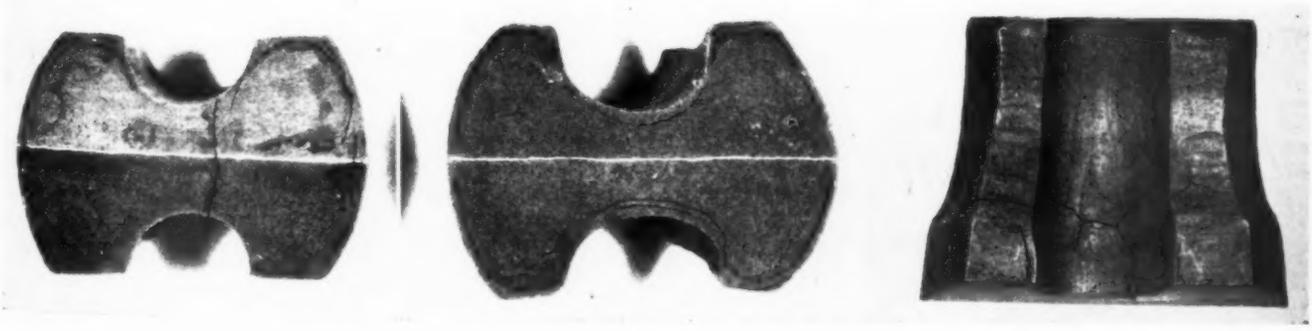


Fig. 7.
Raising the temperature of the surface of the steel at a rate faster than it can transmit the heat by conductivity to the steel in the center causes the surface to expand faster than the center follows; the result is a rupture or shell. Split water courses are often caused in the same way.

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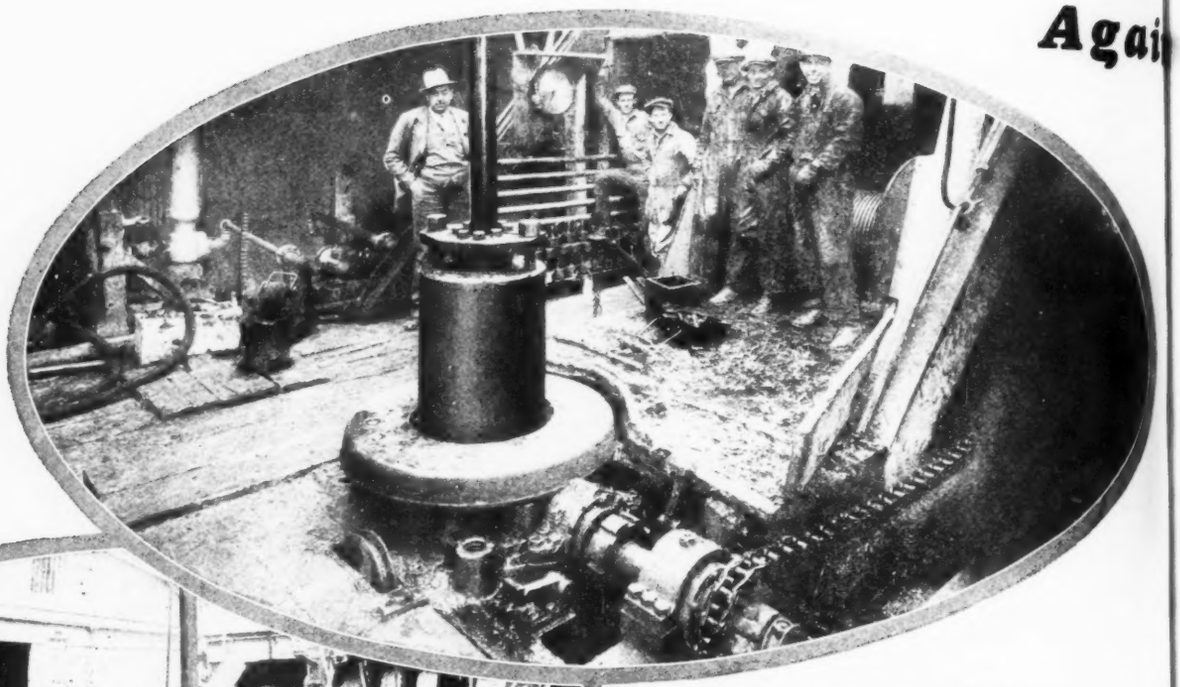

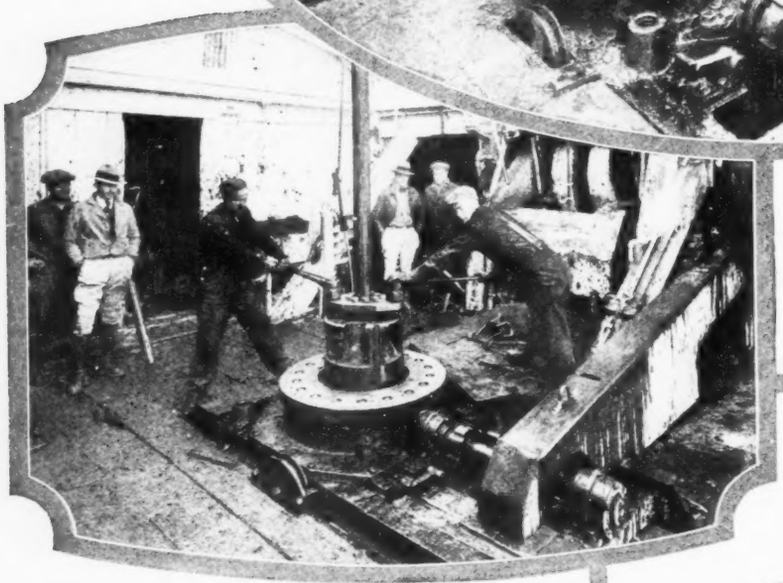

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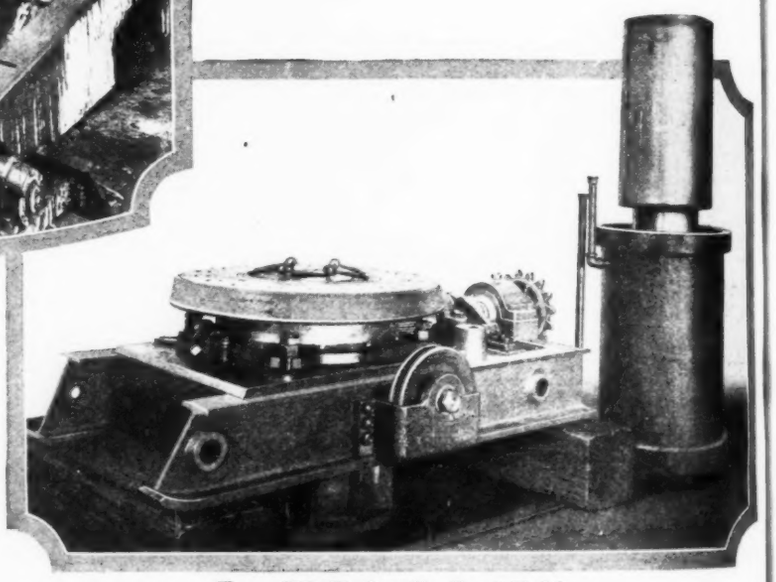
Mills City, Well No. 2, Turner Valley, Calgary, Canada. Drilling depth, 5,284 feet. Circulating with oil, carrying pressure controls for handling three thousand-pound rock pressure.



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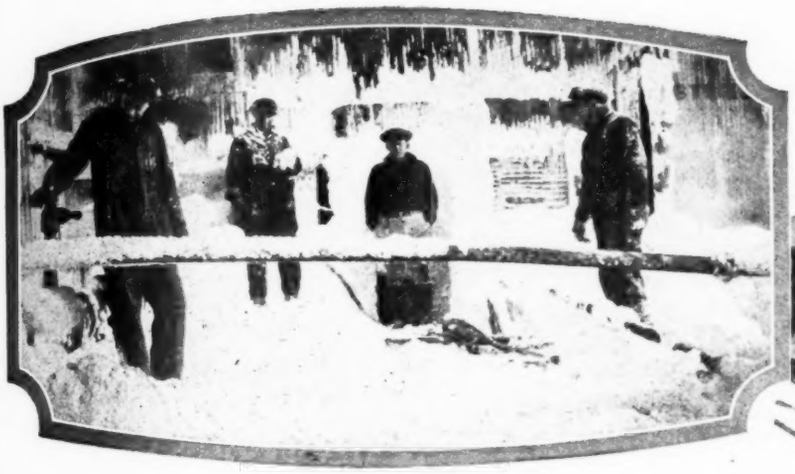

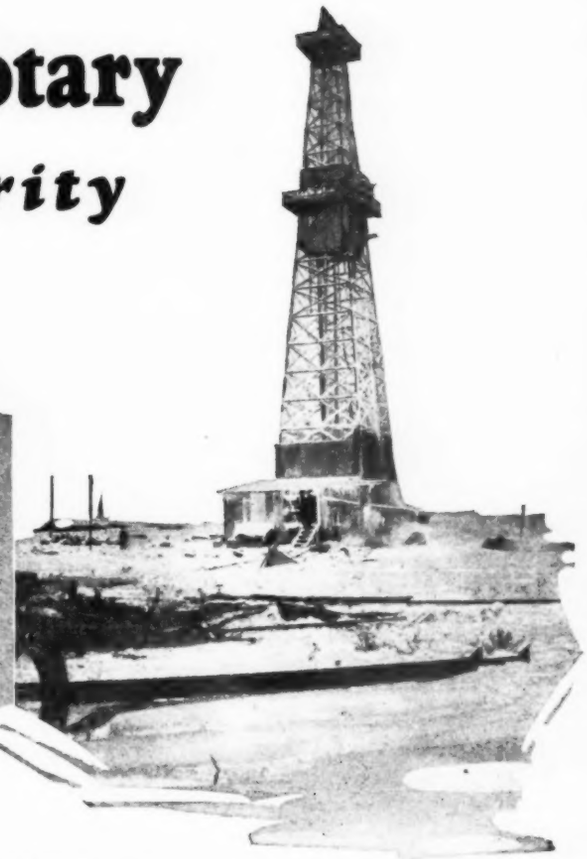

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wearing surface, therefore, is composed of old, cracked, rented and torn steel that has been many times reheated, oxidized and decarbonized and sometimes burned. These conditions cause buckles and cracks both on the wearing surface and in the heel above it. Such a wearing surface will drill but little before it wears and breaks out of gauge. Adequate time in preheating and final heating will put the core, as well as the surface, in a good plastic condition and it need not be overheated. In such a condition it may be easily and properly upset instead of "riveted," thereby bringing out to the wearing surface new sound steel to replace that previously worn away, and at the same time it swells the body above the wearing surface, lengthening it and giving it a real support. Such a bit will unquestionably give much more service, will spawl off much less, is not likely to break off in large pieces and will drill a rounder, straighter hole. For surface conditions resulting from proper and improper heating and stoving, see Figures 5A and 6A. For interior flow or work lines, see Figures 5B and 6B.

The overheating of steel is one of the most numerous and serious causes of trouble with bits. It would be rather difficult to define the line between overheated and burned steel. Figure 1, plate "L," shows a slight burn. Figure 1, plate "O," shows a destructive burn. As previously stated, overheating of steel in a rich flame is not nearly so dangerous as in a lean or oxidizing flame. If only overheated, it has developed a very large unbalanced grain structure, in which case it does not always follow that it has been rendered useless, but it may become so if shocked by work, and even if not shocked unless proper steps are taken to recondition it. Used in or forged in, the condition caused by overheating will result in ruptures that make it useless. Overheated steel (see Figure 2, plate "H"), when not ruptured from work or oxidization (burning), should be immediately covered with some heat-retaining substance such as lime, ashes, cement, or even coated with borax, and allowed to cool. The retarded cooling and absence of work shocks will reduce the danger of bursting. The covering will prevent further decarbonizing and oxidization (see Figure 4), and during the slow cooling the first step of the grain correction will take place. When cooled below color, it should be heated slowly to a cherry red, then allowed to cool below color in the air, or preferably under cover, after which it may be reheated for dressing. When heated for dressing, all melted corners, etc., should be trimmed off so as to get below the decarbonized and porous surface, after which it may be dressed. As previously stated, high heat causes grain growth and consequently the higher the heat the greater the grain size, the thicker the grain boundaries, and the harder it is to again reduce them to correctness. The foregoing procedure is a simple method of correcting the grain size and absorbing the grain boundaries. See Figure 10, which shows the results obtained by this method.

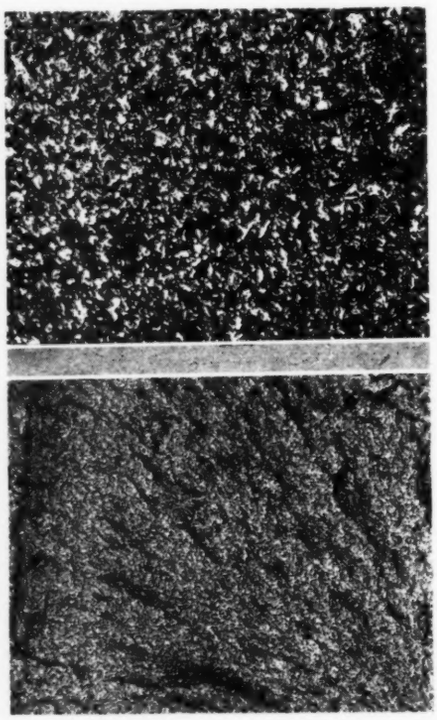


Fig. 10. Results of reclaiming overheated steel. Above, magnified; below, actual break.

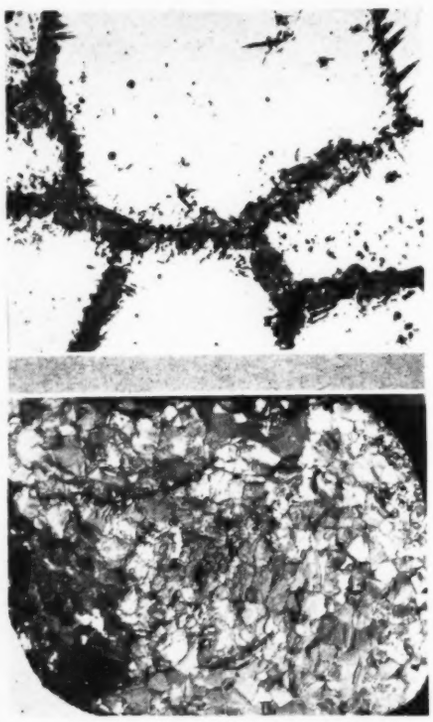
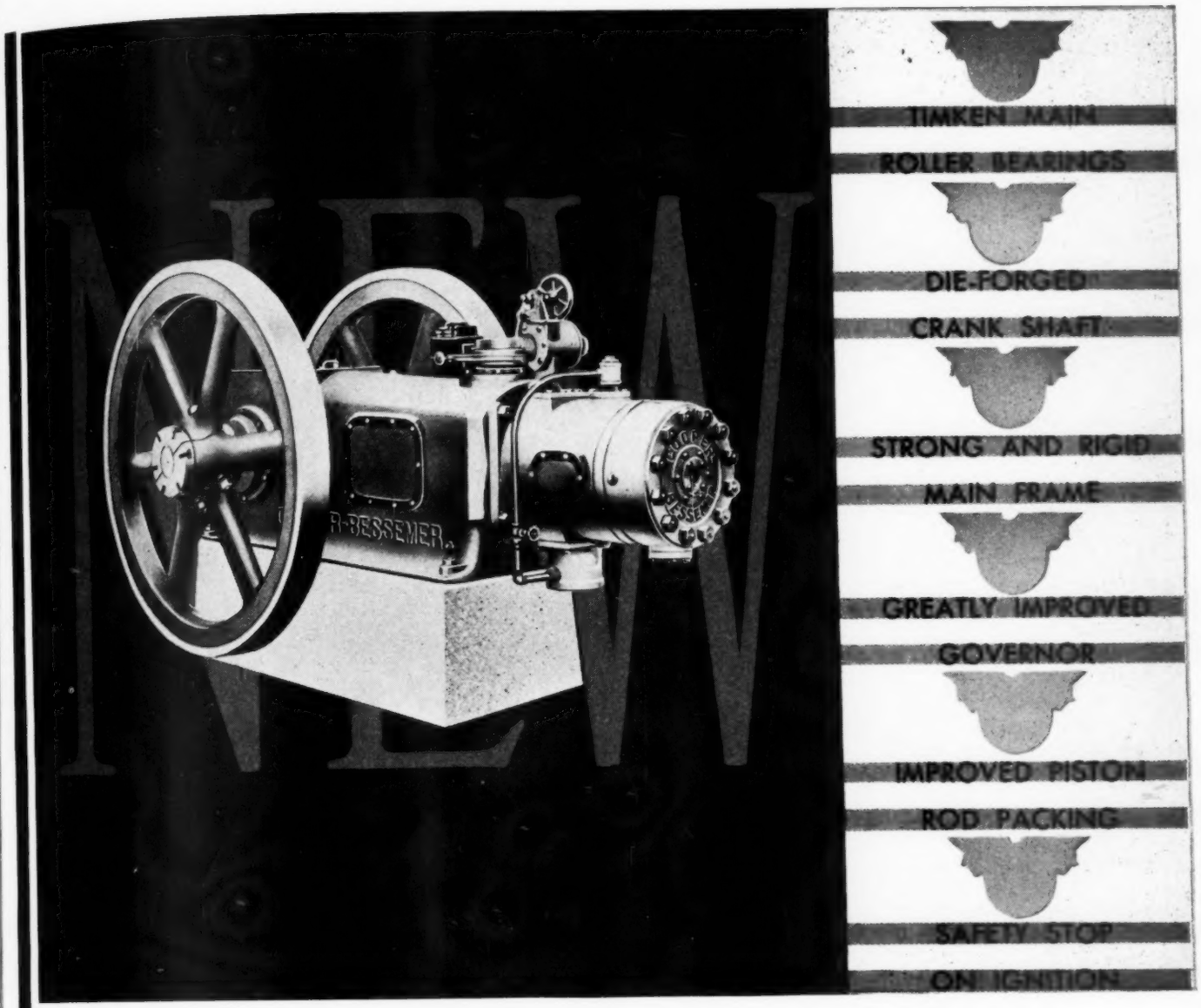


Fig. 11. Burned steel. Above, magnified; below, actual break.

There is yet no way of reclaiming burned steel except to remelt it into new steel. If slightly burned (see Figure 1, plate "L"), it may be "pared off" by taking a shaving off deep enough to reach the bottom of the ruptures or pock marks. However, if very extensively burned (see Figure 1, plate "O"), the whole end should be cut off, using particular care not to again burn the bit when heating to cut it off. For burned steel micro-photographs see Figure 11, also Figure 2, plate "K."

The reaction of the tool dresser and driller to any suggestion of the proper heat to use to dress a bit seems to center on the fact that he has no temperature-indicating instrument to tell him when the proper heat is reached. In this connection it is well for those interested to know that the use of heat-indicating instruments in forge shops for designating proper forging temperature is indeed very rare. Most all forge men depend on their vision and the looks of the steel, taking into consideration the combustion conditions within the furnace. Constant practice and visual comparatives, of course, aid them in their work, consequently it is very rare that steel is spoiled by them by either overheating or burning.

There are many ways of telling the proper forging heat, but perhaps the most easily adapted to men who use it but intermittently is by noting the condition of the scale. In this method it is most important to see that the fuel mixture is of right proportions; if so, the scale will form slowly, will be relatively thin, and at the proper forging temperature it should raise in small blisters. When these small blisters raise, they approach incandescence and the bit



THE name and fame of Type-OF pumping and drilling engine have been established by the more than 30,000 units now in service. In order to widen this leadership, Cooper-Bessemer engineers have done considerable research and experimental work and have conducted a great many tests. The result is TYPE-GA. At no increase in price, TYPE-GA combines all the good points of the old TYPE-OF with the six outstanding improvements listed above. ASK FOR DETAILS.

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should be immediately removed from the forge and dressed. Scale is a natural blanket-like protection to the steel; when it loosens and raises, it is a danger signal. Therefore, under no circumstances should the bit be left in the fire until the incandescent spots enlarge or until all the scale becomes incandescent and starts to run as slag, nor until "bald" or scaleless spots appear, thus allowing both carbon and iron (yellow-jackets) to freely escape. If sufficient time is allowed to let the heat develop properly, a melting heat will not be needed to make the bit fully plastic. If the heat is right the scale will fall freely away as the steel is worked and it should have a fine-grained, satin-appearing texture. If the scale sticks to the steel, it was either too hot or too cold, or the fuel mixture too lean. If too hot, the scale will be thick and porous; if the mixture was correct, it will have a shiny, damp look. If the mixture was too thin, it will be spongy, dull and dry-looking. If this method is tried, proper heating can be done by the average person with but little difficulty.

The question is often asked as to what to do in case a heat is ready and the dressing cannot be done immediately. This should be avoided by careful forethought whenever possible, but due to the unusual conditions that may arise in drilling it will sometimes happen, and when it does there is only one safe thing to do and that is to change the fuel mixture to an extremely rich one by reducing the volume of blast to the minimum. This will prevent further heating and will tend to carbonize rather than to decarbonize the steel. It will not, however, retard the grain growth which is very rapid at the forging temperature. (See Figure 2.) If borax is available, it may be used as a coating to advantage in such emergencies.

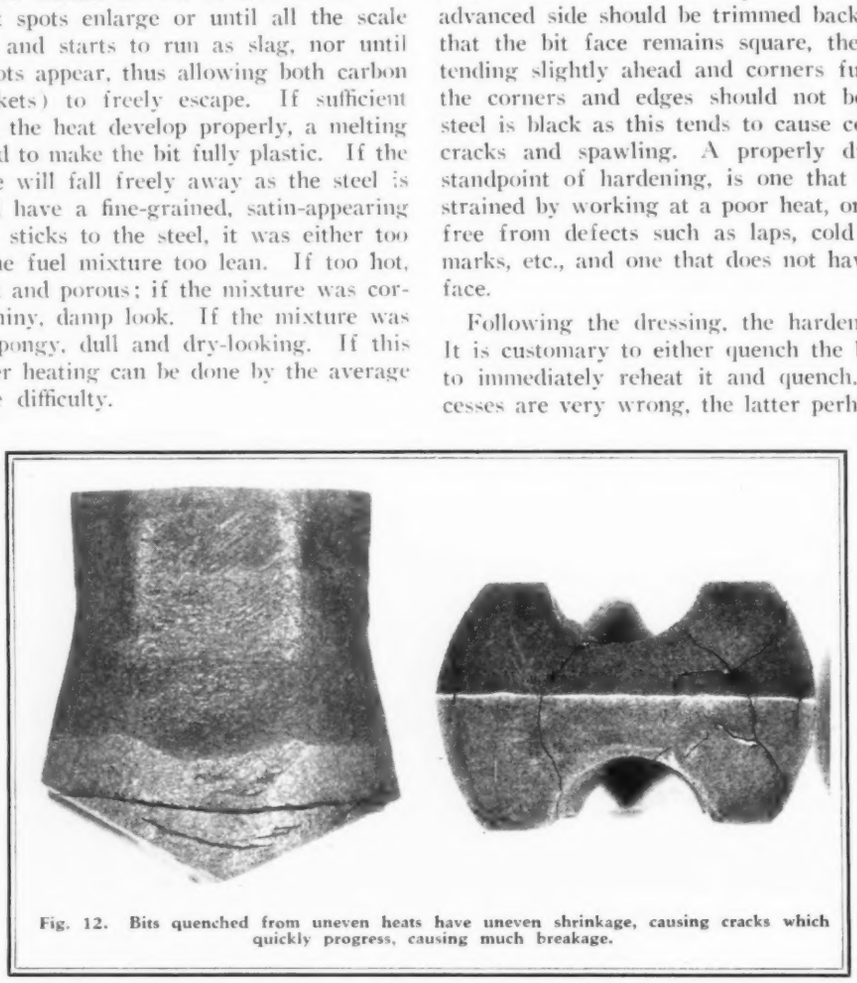


Fig. 12. Bits quenched from uneven heats have uneven shrinkage, causing cracks which quickly progress, causing much breakage.

The actual dressing of bits is not a question to be considered here, as those in the field know from actual experience the shape and type of dressing best suited to their ideals and needs. However, a few things that affect the action and use of the steel may well be brought to their attention. The blows of the sledge or ram should be heavy and directed fairly and accurately at the face of the bit in order that an actual stoving-up action may take place. Cornerwise and light blows (see Figure 1, plates "E," "F," "G," "K" and "L") aimed at spreading or washing of the surface of the steel toward the wearing surface of the bit, tends to pull and tear it apart and causes split water courses, ruptures and laps or cold shuts to form, and also gives no backing up for the wearing surface. For surface condition and interior flow lines of improperly heated and stoved bits, see Figures 5A and 5B. For those of properly heated and stoved bits, see Figures 6A and 6B. The overflow of steel in the water course may be reduced by careful dressing and keeping it down as formed. However, when a surplus does accumulate, it should be removed with a gauge instead of a splitting chisel and all nicks or cracks should be eliminated, otherwise they will develop into fractures. (See Figure 1, plate "C.") The water course may safely be trimmed with the oxy-acetylene cutting torch only provided the bit has been heated sufficiently to show color. Seams should always be fully removed and the advanced side should be trimmed back, when necessary, so that the bit face remains square, the center or backbone tending slightly ahead and corners full to gauge. Finally the corners and edges should not be pounded when the steel is black as this tends to cause cold slips, resulting in cracks and spawling. A properly dressed bit, from the standpoint of hardening, is one that has not been unduly strained by working at a poor heat, one that is smooth and free from defects such as laps, cold shuts, cracks, chisel marks, etc., and one that does not have a hollow center or face.

Following the dressing, the hardening must take place. It is customary to either quench the bit from the anvil or to immediately reheat it and quench. Both of these processes are very wrong, the latter perhaps much worse than the former. It has been previously stated that one of the charactertistic things about steel is that when heated it is subject to grain growth (see Figure 2), and that the grain size does not change when cooling. The only way that the grain structure of steel may be made the size wanted, is to allow it to cool from the plastic (soluble) condition into the non-plastic condition and then reheat it to the temperature which forms the desired grain structure.

The point at which this change of condition takes place is known as the critical temperature. Below this temperature, no perceptible change takes place in the grain unit. As this temperature is passed when heating steel, the minute particles or units are said to go into solution; that is, they separate into the smallest units possible. (See Plate A, Figure 2.) If quenched from this or a slightly higher temperature, an ideal structure is the result. However, if heated to still higher temperatures, these units attract each other, resulting in the formation of larger units and thicker grain boundaries. (See Plates B to J, Figure 2.) As the finer grain structure is both harder and stronger, it naturally follows that the lowest quenching temperature that will produce thorough hardness is the one that will yield the most satisfactory results.

Bits drill good holes or drill bad ones, straight ones or crooked ones, drill fast or slow, are expensive or economical, either as a result of care or of misuse. Anyone of fair ability can give them proper care and thus gain much. If, in the future, as in the past, they are looked upon as a necessary evil, they will continue to be the source of a great loss. If, on the other hand, they will be used and cared for as one of the most important articles in use to reduce the cost of drilling should be cared for, one can look for and expect such a reduction.

Is it not the duty of all those responsible in any way for their use to do their full share in gaining such benefits?

Applying Temperature Control Equipment *to* Petroleum Operations

By R. D. BEAN[1]

THE application of an automatic control device to a process is usually a problem of controlling the supply of a medium in response to some measured change of conditions in the process itself. Under favorable conditions the control instrument changes the position of the control device—a valve, for example—only when the demand of the process itself requires such a change.

Other variables are usually present to complicate the problem, however, and many corrections are made which otherwise would not be necessary if the effects of these variables could be foreseen and independently corrected before they unbalance the process.

Many temperature control applications, for example, require a continual shifting of the control valve position, although the demand of the process may be quite steady and the process may be one which naturally tends to balance itself. The cause is traceable, in many cases, to the fact that a definite valve position does not always produce a definite rate of fuel supply. The deviation, in most cases, is caused by changes in pressure and temperature of the fuel.

The additional complication causes either an unsatisfactory control or it necessitates the purchase of more expensive control equipment having more refinements than should ordinarily be required for the specific application. In many cases it is possible to control some of these variables independently or at least to hold them within reasonably close limits. In such instances the effect of the variables can be eliminated or made negligible in the final result and the main control apparatus can be correspondingly simplified. The addition of a strainer in a fuel oil line or a pressure regulator on a gas line may mean the difference between a successful installation with comparatively inexpensive control equipment and a complicated installation costing two or three times as much in order to produce the same final result.

Further than this, it is not always possible to eliminate some of the variables entering into the process. Changes in the temperature caused by these variables must then be detected later on in the process and the necessary adjustments made to counteract their effects. This introduces a condition which might be termed "process lag" because it represents a time lag over which we have no control. All that the control equipment can do, in such a case, is to apply corrective measures as promptly as possible after the effect has been indicated at the control instrument. It is obvious that the temperature responsive device must be made as sensitive as possible, otherwise the delay will be increased by the inherent time lag of the control device itself. The sensibility of a thermocouple with small thermal capacity is a most important factor in determining the success of many temperature control applications. It is unfortunate that most control problems must be tackled at the wrong end of the process. We install control apparatus for the purpose of eliminating temperature changes in the process and many times the control device is forced to make adjustments long after these variables have affected the final condition in which we are interested. In order to reduce the cost of a control installation it is customary to use a single instrument which will not only control, but will also indicate and record the temperature.

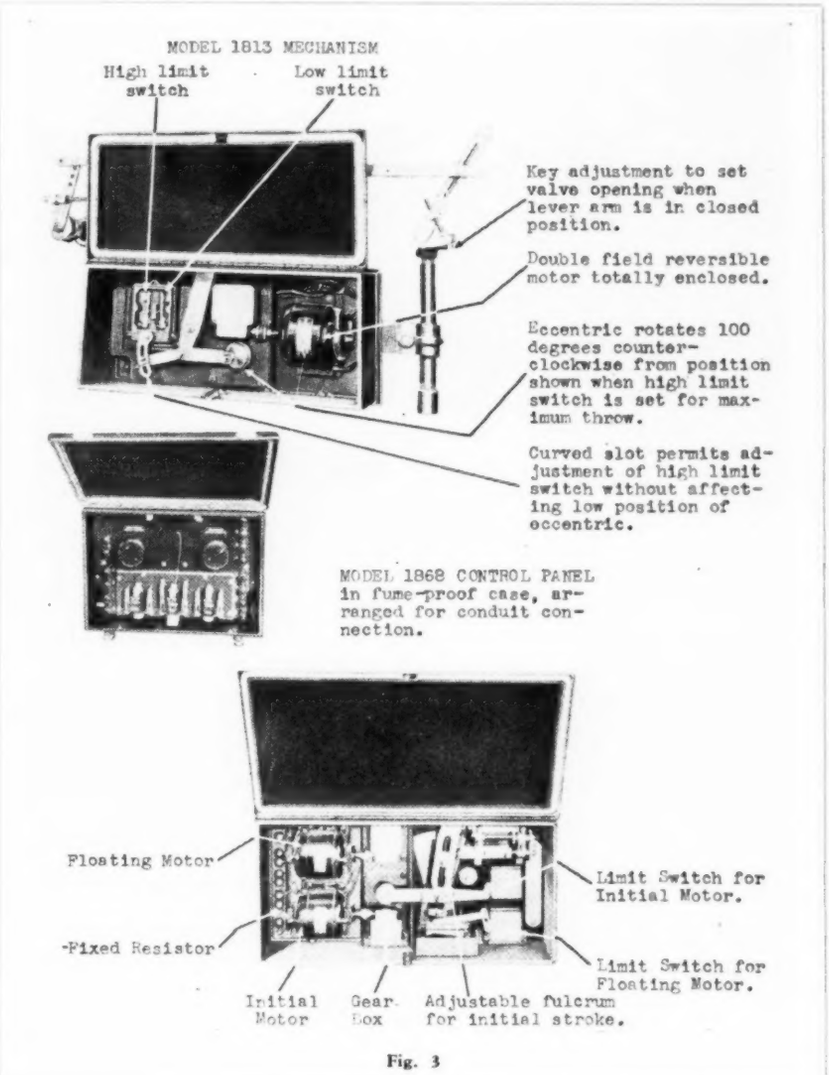

MODEL 1813 MECHANISM
High limit switch
Low limit switch
Key adjustment to set valve opening when lever arm is in closed position.
Double field reversible motor totally enclosed.
Eccentric rotates 100 degrees counter-clockwise from position shown when high limit switch is set for maximum throw.
Curved slot permits adjustment of high limit switch without affecting low position of eccentric.
MODEL 1868 CONTROL PANEL in fume-proof case, arranged for conduit connection.
Floating Motor
Fixed Resistor
Limit Switch for Initial Motor.
Limit Switch for Floating Motor.
Initial Motor
Gear Box
Adjustable fulcrum for initial stroke.

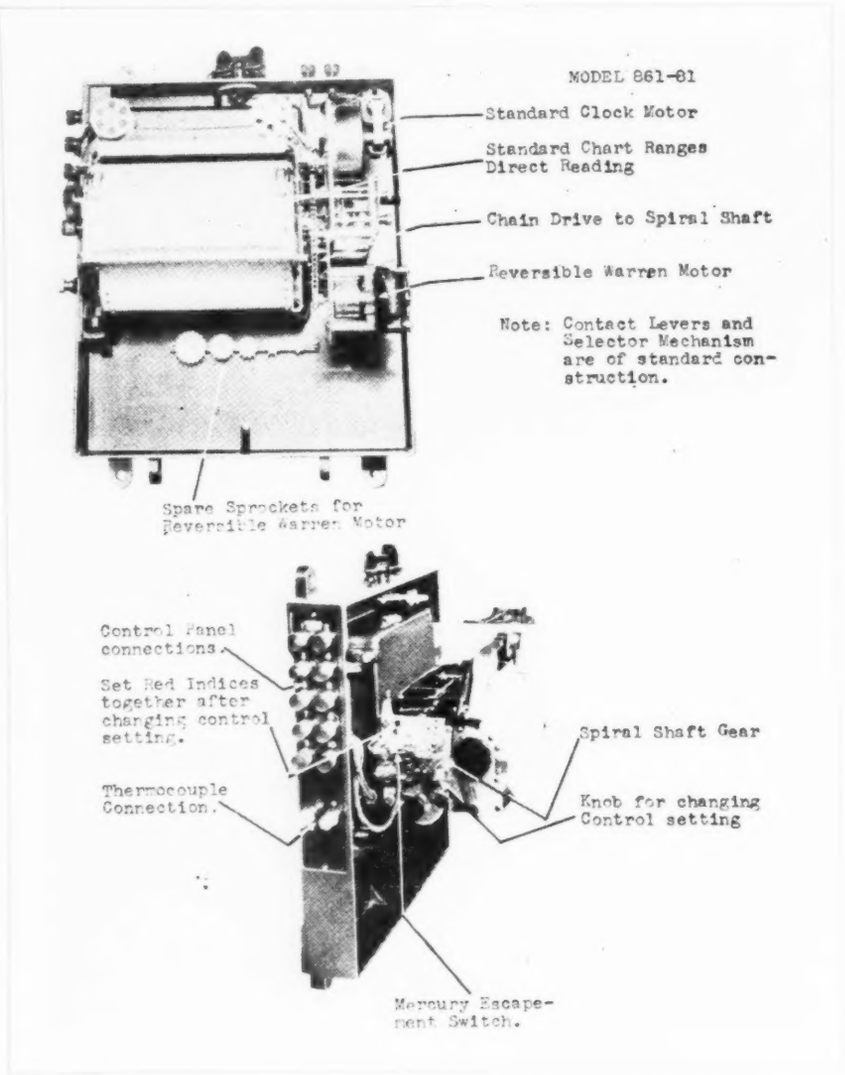
Fig. 3

[1]Manager Engineering Development, The Brown Instrument Company, Philadelphia, Pa.

As a result, many applications are made more complicated than they would be, ordinarily, and the control equipment is required to possess certain refinements and characteristics which would not be necessary if the control thermocouple could be placed in a location different from that where the final result is to be measured and recorded.

In addition to the inherent advantages of the sensitive thermocouple, refinery operating temperatures naturally fall into the range where the electric pyrometer is the most practical measuring device to use. There are also other reasons why pyrometer control has made such rapid progress within the past few years. The various units which make up the control system can be changed independently. If the thermocouple needs replacement, the change can be made in a few minutes and the other units need not be disturbed. Likewise, a motor or a relay can be replaced or the mechanism can be moved to a different location without disturbing the control instrument.

Motor-driven control valves naturally lend themselves to use in conjunction with pyrometer control instruments, and offer a flexibility which cannot be easily obtained in other systems. The requirements for various power ratings are met by merely changing the size of the motor. The control mechanism itself may be located any distance from the control instrument without introducing the slightest time lag in the responsiveness of the control equipment. This same flexibility allows the grouping of a large number of control instruments in a central control house and the problem of installation is greatly simplified.


MODEL 861-81
Standard Clock Motor
Standard Chart Ranges Direct Reading
Chain Drive to Spiral Shaft
Reversible Warren Motor
Note: Contact Levers and Selector Mechanism are of standard construction.
Spare Sprockets for Reversible Warren Motor
Control Panel connections.
Set Red Indices together after changing control setting.
Thermocouple Connection.
Spiral Shaft Gear
Knob for changing Control setting
Mercury Escapement Switch.

In choosing the proper type of control equipment to use on a specific application, we should not only analyze the process which is to be controlled, but we should decide what operating characteristics the control mechanism should have to meet the particular requirements. For this reason it appears desirable to classify and discuss briefly the most common types of motor-driven control devices, with particular reference to their operating characteristics.

Types of Control Mechanisms

Prospective users of automatic temperature control equipment of the pyrometer type will find that a large variety of combinations are offered. Each type will be found suitable for a number of different applications, and the selection of the proper type of control device should be based primarily upon what operating characteristics appear most desirable for the specific application.

A complete discussion of the mechanical features and the various refinements found in control mechanisms is beyond the scope of this article, but the following paragraphs will broadly classify the types which are most prevalent in present-day refinery practice. A brief discussion of the general types will also serve to point out their characteristics and help us to understand the limitations of each. A very broad classification of the types of motor-driven valve mechanisms in common use would divide them into two general groups.

In the first group we have those types which move the control valve through a definite adjustable step. This definite step may occur infrequently or it may occur at fairly regular intervals. In practically all mechanisms of this type the lever completes its stroke in one continuous movement after the motor is energized by one of the control contacts in the instrument. The time required for a complete stroke may be from five seconds up, but seldom exceeds thirty seconds.

Two-Position Control

The principal limitations of the two-position control mechanism, on many applications, is the sudden change in the quantity of controlled medium. This action would be particularly undesirable in some furnace controls where a movement of the valve would produce an appreciable change in the flame.

In order to minimize these surges and to avoid large swings in the temperature, particularly on those applications where the time lag is appreciable, the operator will frequently reduce the movement of the valve by adjusting the limit switches so that a movement of the valve mechanism from one position to another will cause only a small change in the flow of fuel to the burners. This reduction in the amount of valve movement tends to reduce the surges and the resulting temperature control record will show a saw-tooth line of fairly small amplitude, as shown on the accompanying chart (Fig. 1).

Such an arrangement might be satisfactory under conditions where the fuel pressure and the demand on a furnace

9,580,173 Barrels *in 306 operating days*

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Total number of barrels pumped	*9,580,173*
Total hours in service	*7350.5*
Average pressure, pounds	*640*
Total KWH used	*2,097,200*
Barrels per KWH	*4.56*
KWH per barrel	*0.22*
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are quite steady, but a change of pressure in the fuel line or a change in the furnace load will probably require a readjustment of the valve positions corresponding to the two positions of the operating mechanism.

For example, the operator might change the mechanical connection between the motor mechanism and the valve so that the valve would operate between one-half open and two-thirds open instead of between one-third open and one-

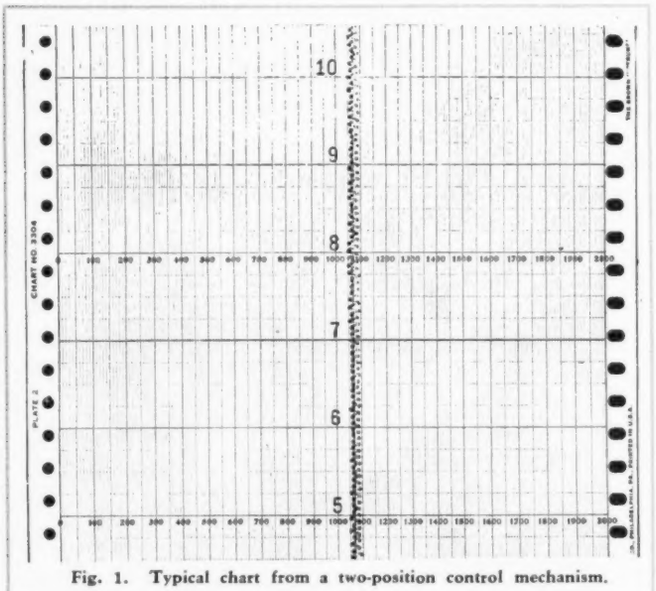

Fig. 1. Typical chart from a two-position control mechanism.

half open. It is evident that the simple on and off or two-position mechanism can be adjusted to produce satisfactory control under specific conditions and it satisfies the requirement of having convenient means of adjustment. It is also reasonable in cost, but may fail to meet the requirements of correct adjustment of fuel supply and capacity to maintain stable operation with little attention.

Three-Position Control Mechanisms

A two-position control mechanism, as outlined in the preceding paragraph, necessarily requires a valve adjustment which allows less than the required amount of controlled medium to flow when in a closed position and allows an excess to flow when the valve is in its opened position. It follows, therefore, that the valve in a two-position mechanism can never remain at rest for any length of time. It can never stop in the correct position (unless the original limit switch setting was incorrect for the required operating range of the valve), but must periodically move back and forth.

This inherent limitation of the two-position mechanism suggests a modification: to add a third position which will be substantially what is necessary to provide a correct flow of the controlled medium at the desired operating temperature. This modification involves the substitution of a three-position electrical limit switch in place of a two-position limit switch and also requires the use of a control instrument having three control contacts in place of the usual high and low contacts.

The operating range of the control valve itself is increased by virtue of this middle or normal position. The valve movement from the middle to the low position or from the middle to the high position can be the equivalent of the stroke of a two-position mechanism, with the result that the total range of valve movement has been doubled.

The second advantage is the "backing off" effect produced when the control valve is moved to its center position from either direction. Suppose the temperature has previously been low (control valve in its open position) and is rising toward the desired normal. When it reaches the center contact in the control instrument the valve will be moved to the center position, reducing the flow of fuel to the furnace and checking the temperature rise.

Conversely, if the temperature has been high and is falling toward the control setting, the valve will be moved from its closed position to its middle or normal position as soon as the temperature reaches the control setting or center contact position. In either case the effect is to change the fuel to prevent overshooting, because the center contact has a certain width and the temperature has an opportunity to line out on the center contact.

The illustration (Fig. 2) shows a typical control record. It is somewhat similar in appearance to the familiar saw-tooth record of the two-position type of control, but the limits are narrower and occasionally we see evidences of the process being balanced with the control valve in its middle or normal position.

This type of equipment has been used extensively during the past year or two in many refineries and undoubtedly is the most widely used type of control mechanism in those applications where the operating conditions do not require or justify the refinements which may be obtained in the more expensive types of control mechanisms. Experience has proved that the three-position type of control mechanism will improve almost any control where the two-position type has formerly been successful in maintaining the temperature within satisfactory limits.

Two-Motor Mechanisms

By adding a second motor to a control mechanism, the operating range of a three-position mechanism can be increased to cover the entire range of the control valve,

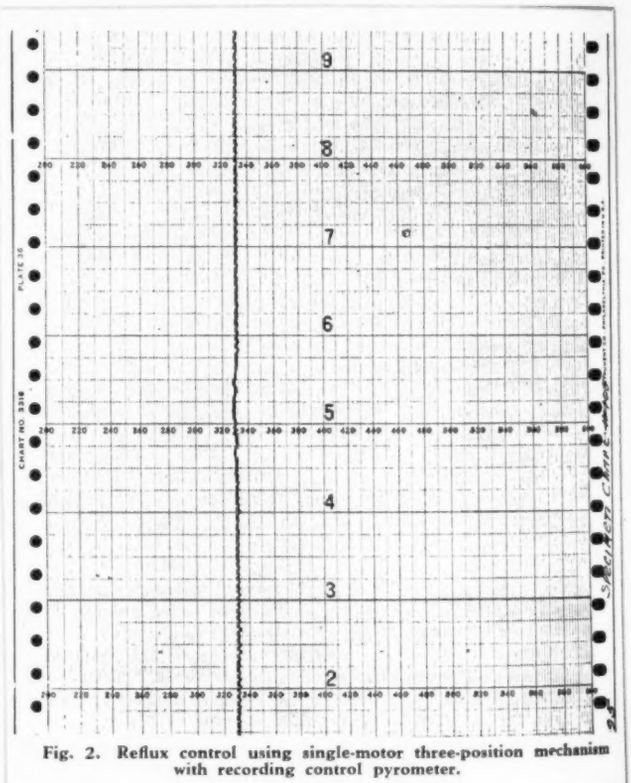

Fig. 2. Reflux control using single-motor three-position mechanism with recording control pyrometer.

thereby eliminating the necessity of manual readjustments when appreciable changes occur in furnace demand or fuel line pressure.

The illustration (Fig. 3) shows the construction of a floating three-position type of mechanism. The term "floating" three-position indicates that while the action of the mechanism is primarily that of a three-position type, the

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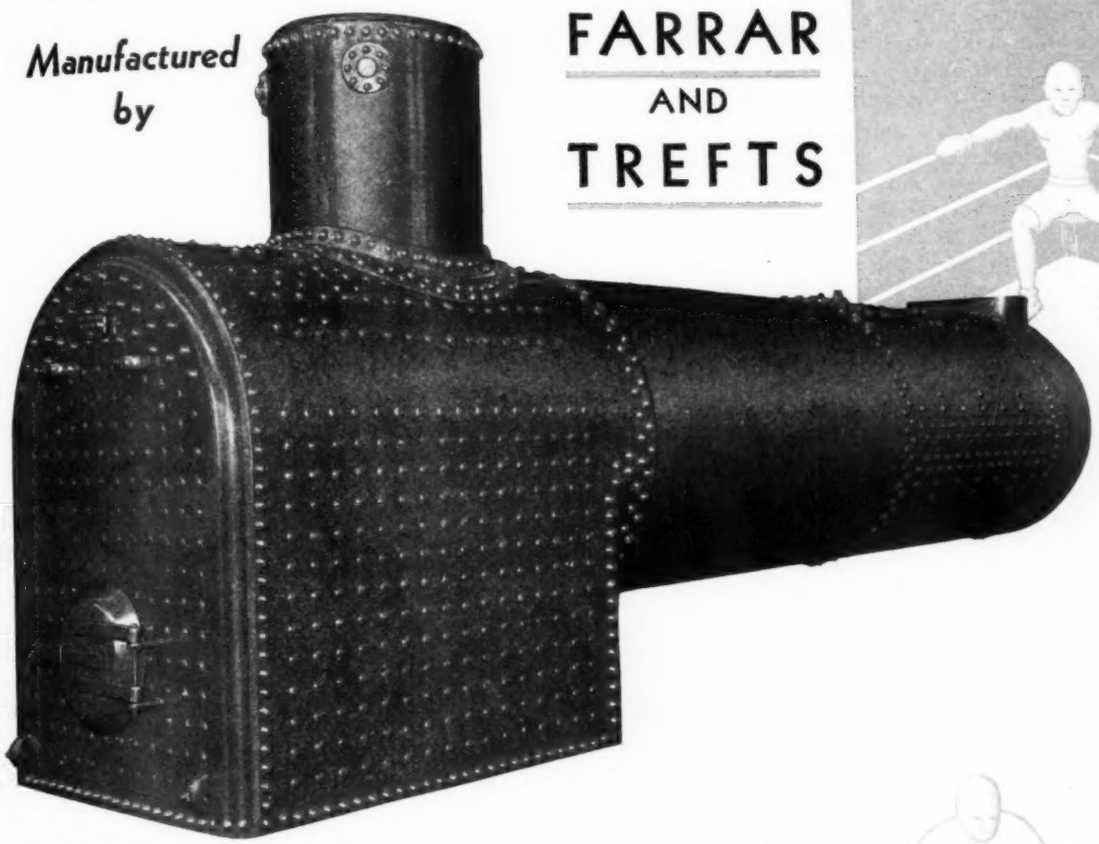

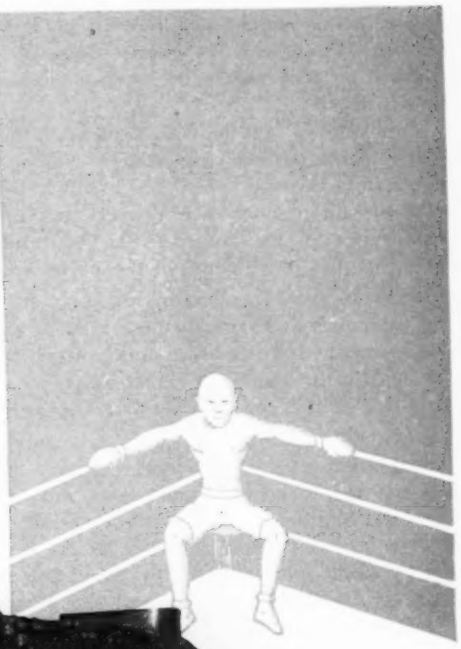

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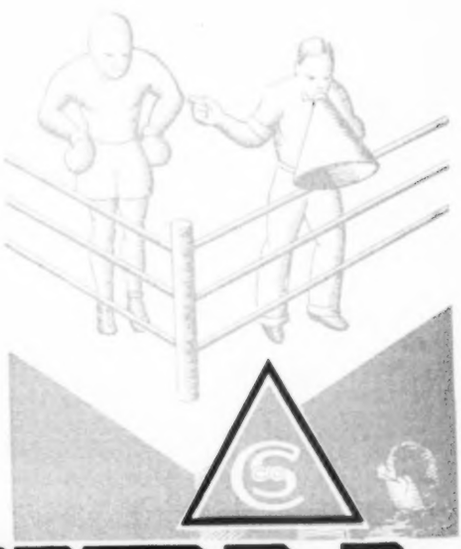

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second motor enables the mechanism lever arm to take any position throughout its entire range of movement to correspond to the middle or normal position of the initial stroke motor.

This type of mechanism combines the advantages of the simple three-position mechanism with the wide operating range of a floating type. Its greatest field of usefulness is in those applications where operating conditions require a wide range in the control valve movement but where the three-position movements of the valve are not objectionable.

It can be used in combination with the same type of control instrument previously described in connection with the single-motor three-position mechanism and the addition of the floating or balancing motor does not materially increase the price of the complete control equipment.

On applications where there is a moderate time lag an arrangement may be provided in which the balancing motor will not move the fuel valve until after the control instrument has had an opportunity to respond to the effect of the change in valve position made by the initial motor. This can be done mechanically by providing a time lag clutch between the floating motor and the mechanism lever arm. The floating motor can then operate for several depressions of the control instrument before the clutch engages to move the mechanism lever.

In those applications where the time lag is particularly great it is desirable to incorporate certain refinements in the control instrument itself in order to minimize the tendency to set up hunting. With proper modifications in the control instrument it is possible to eliminate the time lag factor in the mechanism and to operate the floating motor simultaneously with the initial motor. See Fig. 4.

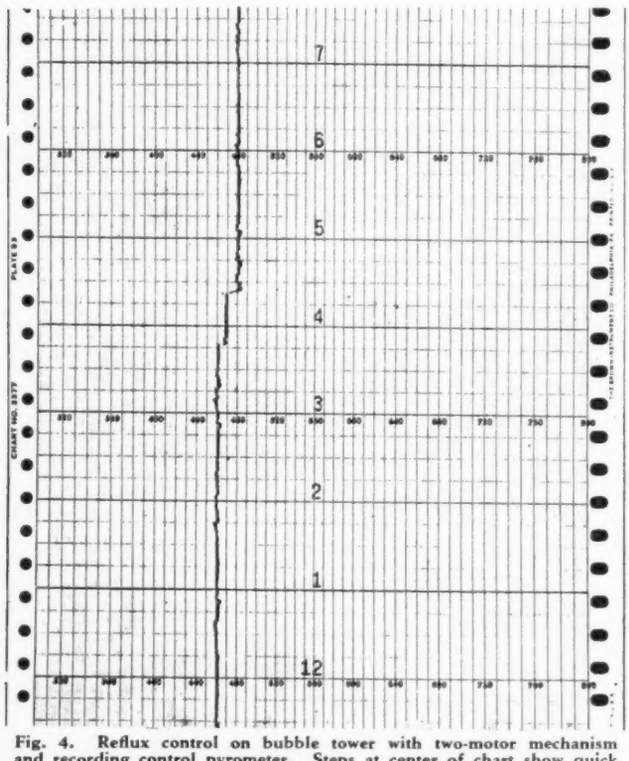


Fig. 4. Reflux control on bubble tower with two-motor mechanism and recording control pyrometer. Steps at center of chart show quick response when operator changes control setting.

In many applications the process may become sufficiently unbalanced to require a large shift in the position of the control valve. The control device, under those conditions, should produce a shifting of the control valve position as promptly as possible in order to arrest the temperature trend before it has had an opportunity to gather momentum.

Floating Mechanism

During the past three or four years the use of automatic temperature control devices in oil refining practice has increased rapidly. The use of automatic temperature control

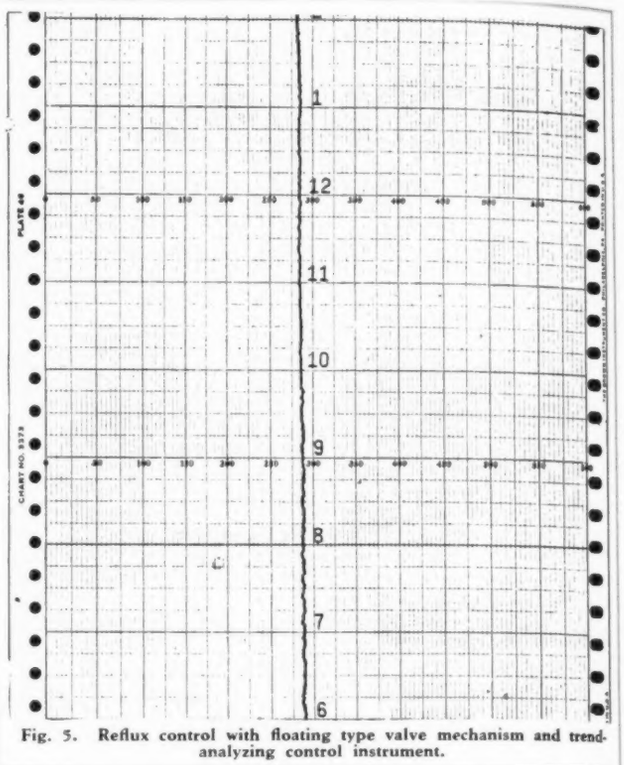


Fig. 5. Reflux control with floating type valve mechanism and trend-analyzing control instrument.

equipment is no longer restricted to the control of bubble tower temperatures, but has gradually embraced a much wider field of application. The success of automatic control equipment on bubble towers suggested the possibility of controlling furnace temperatures and hot oil temperatures within closer limits in order to increase the yield and to obtain a product of more uniform characteristics.

Some of the newer applications require a type of control mechanism which is capable of moving a control valve in very small increments when the process is nearly balanced, and to move the valve rapidly in case any appreciable unbalancing of the process should require a rapid change in the valve position. See Fig. 5.

Many of the new applications involve large thermal capacities and appreciable time lags, and the problem of hunting has stood out more prominently than that of correct fuel adjustment. It was an easy matter to construct a control mechanism which would take very small steps with each depression of the control instrument. It was also an easy matter to provide one or more auxiliary contacts on the control instrument to make a large correction or to produce continuous running of the motor if the temperature should depart beyond a certain fixed limit. Neither of these schemes proved very satisfactory.

Previous developments in control apparatus had been confined largely to improvements in the motor mechanism itself. At this stage in the development it became evident that further improvements in the art of temperature control would have to come primarily from refinements in the control instrument and not through added complication in the valve mechanism.

Automatic Control Pyrometers

An automatic control pyrometer might be termed a temperature governor, and a discussion of the requirements which it should satisfy may perhaps be best understood by reference to other types of governors. The desirable oper-

ating characteristics of a good temperature governor can perhaps be discussed by drawing an analogy from a relatively simple type of mechanical speed governor.

We have all seen a centrifugal speed governor on a steam

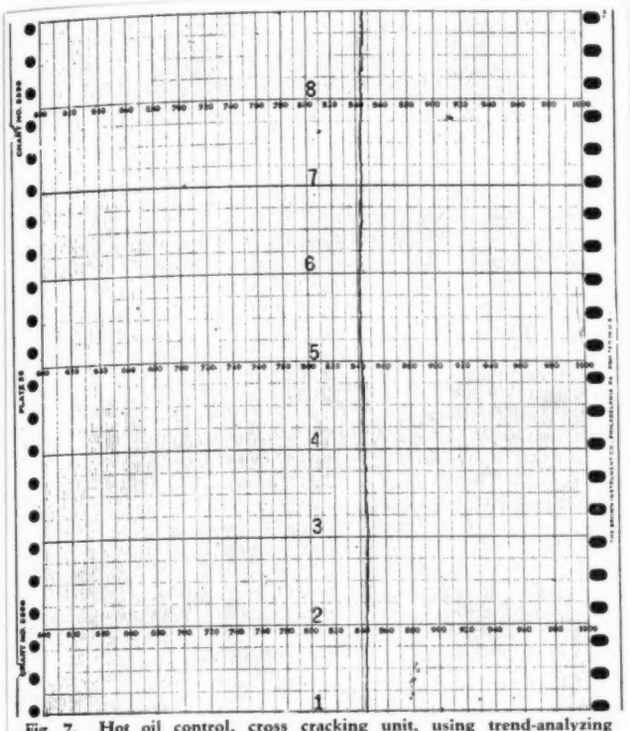


Fig. 7. Hot oil control, cross cracking unit, using trend-analyzing type of control pyrometer in conjunction with single-motor floating type of control mechanism.

engine. If the steam pressure increases, the speed of the engine increases and the rotating balls rise to cut down the supply of steam and prevent a further increase in speed. If the load on the engine changes, the steam supply must be altered and a certain displacement of the rotating balls is necessary to effect this change. It is evident that the balls can retain their displaced position only by virtue of a permanent change in the speed.

Knowles overcame this limitation by adding a supplementary governor which acted by lengthening a rod which connected the ordinary governor to the steam valve. With this combination, any sudden fluctuation in speed was immediately responded to by the ordinary centrifugal governor. A permanent change in steam pressure or in the load on the engine gave the supplementary governor an opportunity to gradually correct the control setting so that the first governor could return to its normal position and so leave the steam valve in its new position.

The principle of this governor might be briefly stated by saying that the first element responds rapidly to a change in the quantity being regulated and tends to oppose a change in either direction, while the second element responds slowly to the value of the quantity being regulated and readjusts the normal position of the first element.

In temperature control work the term "follow-up" is frequently applied to designate the first element which responds quickly to any change in the quantity being regulated. For each position of the control valve there is a corresponding position of the controlling element.

For purposes of illustration we can imagine a very simple type of follow-up control device applied to control the temperature of a furnace. A metal rod could be placed in a furnace, and so arranged that a change in temperature would move a fuel valve attached to one end of this rod. The rod could have a small thermal capacity and could respond quickly to changes in the furnace temperature. If the temperature should rise rapidly, the rod would expand rapidly and the fuel supply would be correspondingly decreased.

Conversely, a sudden fall in temperature would result in a rapid contraction in the rod and a rapid opening up of the fuel valve. This simple follow-up control would fail to hold the temperature at the exact point desired, because after having departed from normal to move the valve to a new position it cannot again return to normal as long as the valve must be held in its new position. Any form of throttling control device having only this one stabilizing characteristic must sacrifice some of its accuracy in the exact maintenance of the value desired.

If the pyrometer moveable coil had unlimited power it would be a simple matter to produce a follow-up control action by directly connecting the control valve. Since the available force is extremely small, this follow-up action must be produced in another manner.

A convenient method of producing the desired result is to shift the neutral of the control instrument with each movement of the valve. After each adjustment the control table is moved to bring the neutral to the exact location which the pointer occupied previous to the last adjustment.

The effect of such an arrangement is to maintain the valve in a definite position as long as the temperature is steady and to move the valve only when the temperature changes. In other words, for each position of the pyrometer pointer there is a corresponding control valve position. A permanent change in furnace load or in fuel pressure would then tend to leave the control contact permanently displaced from the true control setting.

In order to avoid this and maintain an exact control setting it is merely necessary to add a second control element which will function to move the control contacts back toward the control setting when the pointer selects the center or neutral contact. Since this second control device readjusts the relative positions of the control valve and the neutral in the control instrument, it is the equivalent of the compensator in a speed governor which periodically readjusts the position of the stabilizing element.

The simple type of high and low contact pyrometer possesses the compensating characteristic because it changes the relative position of the control valve with respect to the neutral of the control instrument, but it does not possess the stabilizing characteristics of the follow-up type of control instrument. It maintains an accurate average temperature, but when used in combination with a floating type of mechanism the temperature will continuously hunt above and below the desired temperature.

In selecting a control instrument for use in combination with a floating type of mechanism we should be sure that it has the two necessary characteristics: A stabilizing element which acts quickly to oppose any change in the temperature and a compensating element which can readjust the position of the stabilizing element to maintain the temperature at the exact value desired. There are many control instruments on the market that possess one or the other of these two important characteristics, but there are few that possess both of them.

A reversible Warren motor, through a chain and sprocket drive, moves the selector table so that it follows the pointer. The small reversible motor is connected in parallel with the motor in the valve mechanism and runs simultaneously with it except when the pointer selects the center or neutral contact.

When this occurs, the motor in the valve mechanism is temporarily disconnected and the center contact completes a circuit to one field of the reversible Warren motor. The reversible motor then rotates a spiral shaft which causes

the selector table to take a step toward the true control setting. The side view of the instrument shows the mercury switches which rotate with the spiral shaft and complete a circuit from the center contact to one field or the other of the reversible Warren motor.

The trend-analyzing control instrument is designed primarily for use in conjunction with the floating type of mechanism. The gradual throttling characteristics are very desirable in those applications where the control valve should be moved in very small increments, and where the time lag in the process would produce excessive hunting with the ordinary control instrument with a fixed control table. It may be used in combination with a single-motor floating mechanism or with a two-motor floating mechanism. The two-motor trend-analyzing control is particularly satisfactory on those applications where the control must frequently handle sudden changes in operating conditions. See Fig. 6.

Let us consider, for example, an application in which the control valve may be operating at about one-third of its fully opened position, and let us assume that a sudden change in conditions, either in furnace load or pressure in the fuel line, requires that the valve be opened as rapidly as possible to approximately its full capacity. Under these conditions it is obvious that the comparatively large movement of the initial motor in the two-motor mechanism will tend to correct the condition in its early stages before it gathers momentum.

Accordingly, the two-motor mechanism has a marked advantage in those applications where the temperature has a tendency to change very rapidly and where operating conditions are such that a quick change in the control valve position is frequently required in order to prevent excessive deviation from the control setting.

Selecting the Proper Type of Equipment

After knowing the operating characteristics of the various types of mechanisms, it is not a particularly difficult matter to analyze the requirements of a specific application and to decide what characteristics are most desirable. A few specific illustrations will perhaps serve to illustrate the general principles which have been previously outlined.

Tower Control

There is probably no application of temperature control equipment in an oil refinery where more widely varying conditions are found than those met with in the study of reflux control. In some tower applications the operating conditions are so erratic that a satisfactory vapor outlet control can be obtained only by using the most flexible type of control equipment.

Fluctuating hot oil temperatures, variations in pressure in the tower, changes in the level of the tower bottoms, temperature of the reflux and possibly other variables may all combine to introduce appreciable difficulties. On the other hand, a tower may operate under conditions which are ideal for obtaining excellent results with the simplest type of control mechanism. Experience with a given tower under manual control will invariably suggest what to select in order to get satisfactory results from automatic control equipment.

A tower which operates under a uniform load, possibly in connection with a crude still, and whose supply of reflux comes from a motor-driven centrifugal pump supplying reflux at a constant pressure to the control valve, can be controlled with excellent results with the simple two-position control mechanism.

Because of the steady conditions, the stroke of the valve may be reduced so that it produces only slight changes in the supply of reflux when it is moved from one position to the other. Naturally, a change in the operating temperature may necessitate a mechanical readjustment of the valve position, but these changes may occur only occasionally and may not be at all troublesome to the operator. He may achieve the same result by readjusting a by-pass valve instead of changing the limits of the control valve.

The three-position mechanism, under these same stable operating conditions, offers the advantages of a greater total range in valve movement for a given stroke of the valve mechanism. The greater freedom from manual adjustments, or the closer approach to a throttling effect, may warrant the slight additional cost over the two-position type.

Under less favorable operating conditions it is evident that the control valve will have to have a wide range of movement in order to take care of the many variables entering into the problem. Frequently it will be necessary to move the control valve through a rather wide step as promptly as possible in order to catch a sudden surge of the temperature and to arrest the trend as promptly as possible before it gathers momentum and starts to go through a series of long swings.

There are many times when such a drastic change is not necessary and we shall therefore want the mechanism to be capable of making rather small changes in the valve position when the operating conditions are nearly balanced. We have, then, the problem of meeting a demand for a large valve movement under unusual conditions and a slow throttling action when conditions are stable. The obvious answer to the problem is to select a control mechanism combining those two characteristics. The two-motor type which may be used with a standard three-contact control instrument (or in combination with a trend-analyzing instrument when the problem is particularly difficult) will be our choice.

In this example we have covered almost the whole range of operating characteristics. The possible wide variety of operating conditions requires thoughtful analysis of each tower control problem if we wish to obtain the best possible results in return for the expenditure.

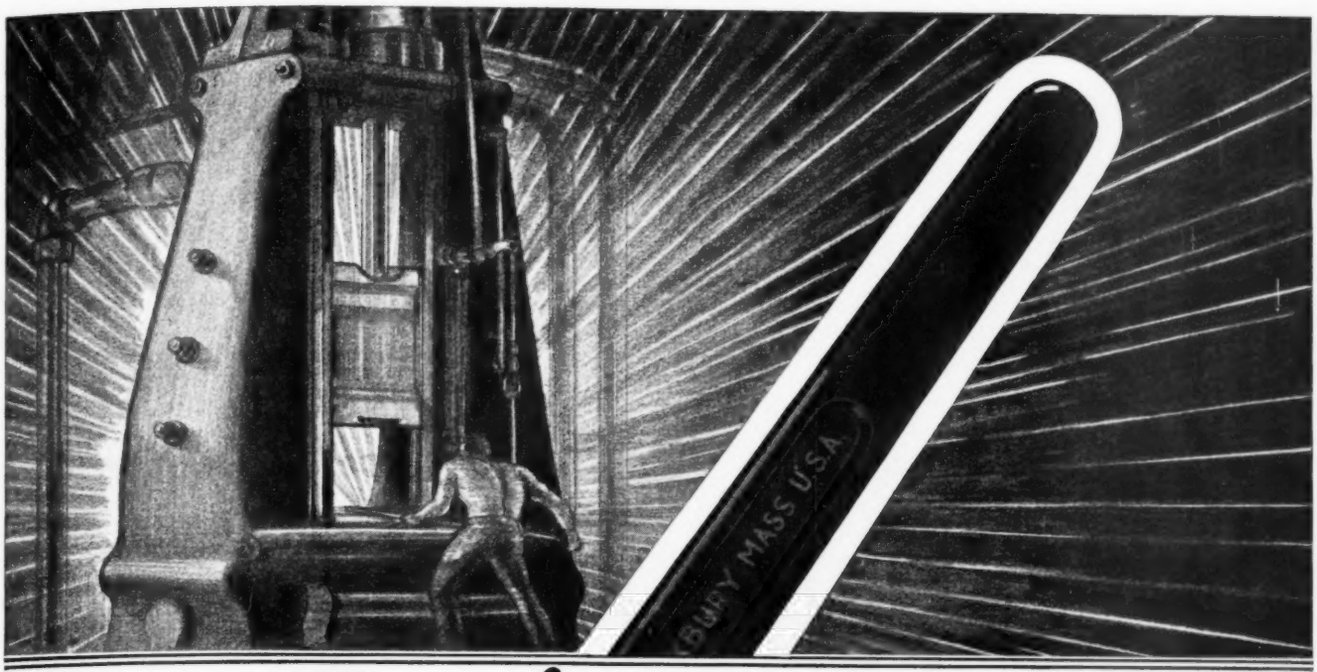
Furnace Control

A few years ago there was a great deal of prejudice against the application of automatic control equipment to furnaces of pipe stills or cracking units. This prejudice was due largely to the operating characteristics of those types of control mechanisms which were in use at that time. The simple two-position type of mechanism was obviously unsuited to the requirements of a satisfactory furnace control.

Sudden changes in flame length could not be tolerated by operators who knew what damage could come from flame impingement on tubes. Furthermore, operating conditions in most units were such that the furnace had to be frequently raised or lowered in order to produce the desired heating effect or the desired final hot oil exit temperature. This frequent change of control setting was not feasible with the two-position mechanism, or even with the three-position mechanism.

The improvements in control mechanisms which possess throttling or floating characteristics have eliminated most of these former objections. The first use of the floating type of mechanism did not produce the expected results because of certain limitations in the control pyrometer, but the development of the follow-up or trend-analyzing type of control instrument effectively eliminated the undesirable hunting which had been previously experienced with the early floating mechanisms. As a result, furnace control of pipe stills or cracking units is becoming more and more common and has proved a very useful and practical advance in the use of control equipment on the larger units.

The operator who is fortunate enough to have a well-designed furnace control on his pipe still is invariably



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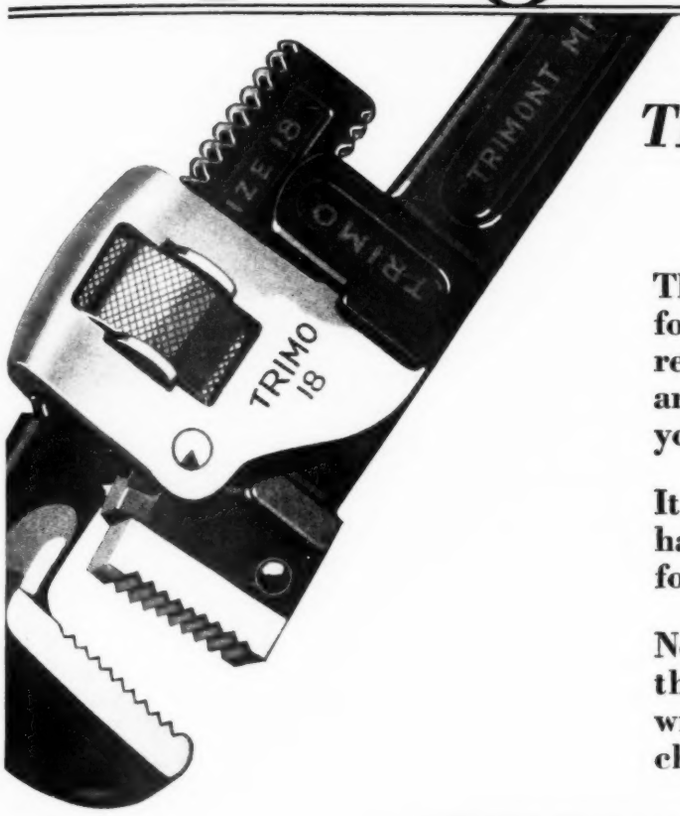

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The choice of the proper equipment is far easier in the case of a tube still furnace control than for some of the other applications. The requirement for a gradual movement of the fuel valve is quite evident, and we therefore choose the type of control mechanism which has this important characteristic. Close control without objectionable hunting necessarily indicates the need for the best type of control pyrometer, which is the follow-up or trend-analyzing control instrument.

To round out our discussion of the proper selection of control equipment for a tube still furnace, it may be desirable to consider one or two details in connection with this equipment. Most furnaces will have two or more burners, either fuel oil or gas, and our control mechanism should control the flow of fuel to the burners with the least possible complication in the installation.

A sub-header should connect all burners and the control valve should control the flow of fuel to this sub-header. Each burner will have a hand-valve to enable the fireman to balance the burners to produce a balanced furnace temperature. When these valves are once set the automatic control valve will vary the supply of fuel to all the burners in the same proportion. This arrangement allows the control instrument to maintain a constant average furnace temperature, but the operator will be responsible for their proper balance.

The furnace thermocouples should be located where they are most responsive to changes in the heating effect on the oil. On a tube still furnace which is run with a small amount of excess air, most of the heat is transferred to the oil by radiant heat. Under these conditions it has been found desirable to locate the control thermocouples down through the roof tubes where they will quickly respond to a change in radiant heat and will indicate the necessary adjustments to the furnace fuel before this effect has been registered at the final hot oil outlet.

Another feature which has been found desirable is to use two or more thermocouples connected in series so they will measure the average furnace temperature. A slight decrease in the temperature at one side of the furnace, caused possibly by a slight clogging at the burner tip, will be compensated by an increase in fuel oil to the other burners and a resultant average heating effect on the oil in the tubes.

When adjusting the valve mechanism care should be taken to set the limit switches so that flame impingement, or too high a furnace temperature, cannot be caused by too great a quantity of fuel passing through the control valve. This precaution is particularly necessary in order to take care of a condition where a furnace is first started up after a shutdown and the operator has set the control instrument for the final temperature which he wishes to obtain.

Hot Oil Control

The control of the hot oil outlet of a tube still involves a number of factors, each of which affects the final result obtained. The subject of hot oil control is a rather broad one and time will not permit us to go into very much detail regarding the various systems.

If the throughput of a tube still is constant, the problem of controlling the hot oil outlet temperature resolves itself in many cases into the direct control of the fuel to the furnace in response to variations in the temperature of the hot oil in the tubes. The problem is then very similar to that of a furnace control, except that the thermocouple which actuates the control instrument is located in a position to measure the temperature of the oil passing through the tubes.

This thermocouple may be located at the final hot oil outlet or it may be located at some point intermediate the inlet and outlet of the tube still. In the case of a small pipe still in which most of the heat transferred to the oil is through radiation, it is generally desirable to locate the thermocouple at the roof tube outlet.

Since the oil receives a large proportion of its total heat when passing through the roof tubes, this location is at the point in the path of the oil where it has just passed through a rather steep temperature gradient. Accordingly, it is particularly sensitive to changes in radiant heat from the furnace, and corrections to furnace fuel made in response to indications in oil temperature at this point will promptly correct any tendency on the part of the oil to deviate from the desired temperature.

Corrections made at this time will generally readjust furnace conditions to smooth out irregularities in temperature before the oil completes its journey through the tubes and the final exit temperature will not necessarily show the variations which were detected at the roof tube outlet. The variations which may appear will be considerably less in extent than those detected earlier in the process.

Since a hot oil control system of this type directly controls the supply of fuel to the furnace, our selection of the proper type of equipment is based primarily upon the same consideration that led to our choice in the case of the straight furnace control. A steady furnace temperature and a constant throughput will result in a fairly constant hot oil outlet temperature.

Such a system as the one just described should be applied to those installations in which the throughput is known to be reasonably steady and constant in value. If this condition is satisfied the control has only to counteract the effect of minor variables such as changes in furnace draft, changes in flame color, changes in the condition of the tubes which modify their capacity to absorb heat, slight changes in throughput and possibly the effect of variations in atmospheric conditions.

Since we apply a system of this type only in those cases where the major variables are steady, we naturally select a type of equipment which makes very slow and gradual changes to the supply of fuel to the furnace. This requires the throttling or floating type of valve mechanism. Since the time lag is undoubtedly greater than in the case of straight furnace control, even with the most favorable conditions, we shall also select the trend-analyzing, follow-up control instrument in combination with the floating valve control mechanism. See Fig. 7.

In any system of hot oil control where the fuel to the furnace is varied in response to changes in the hot oil temperature, unusual conditions may arise where the control instrument might tend to raise the average furnace temperature above desirable maximum limits. For this reason, as in the case of the straight furnace control previously described, the limits of the control valve mechanism must be so adjusted that the temperature will not rise above the desired maximum when the control valve is in its wide open position.

We shall not, at this time, go farther into the details of operation or installation. The few examples which have been discussed here were included primarily to illustrate a practical method of selecting the best type of equipment for a few typical applications. They have served to illustrate the general principle of analyzing a control problem and selecting the combination of control apparatus which has the most desirable operating characteristics for the specific application.

PROPER CARE *of* CABLE TOOL LINES

By WALTER VOIGTLANDER[1]

IN AN endeavor to reach a spirit of co-operation and understanding between the maker and user of wire rope, the Mid-Continent Engineering Sub-Committee presented to the 1928 annual meeting of the American Petroleum Institute a revised set of wire rope specifications. These specifications gave considerable space to the "minority" causes of field trouble, namely to such comparatively few faults as may have their origin in fabrication; and in a very praiseworthy manner set forth practical rules for detecting and evaluating such faults. These specifications seemingly loom large in their responsibility of the manufacturer because of the space allotted thereto, but part of paragraph 23 can be quoted to give proper proportions to the responsibilities of both parties: "The causes for short service can be divided broadly into two classes, the first which is improper handling, use or abuse in the field; and the second is faulty materials, workmanship or fabrication. By far the larger number of complaints are those caused by abuse or by improper handling of wire rope in the field."

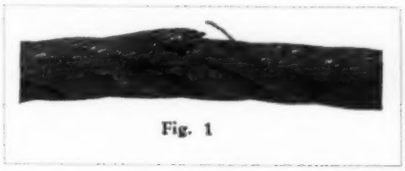

Fig. 1

It is the purpose of this article to enlarge more fully upon this question of field abuse as already covered in outline in Appendix "C" of the A. P. I. Specifications for Wire Rope.

In reviewing complaints of drilling ropes, the causes of short service from field use in order of importance are:

1. Lack of lubrication.
2. Clamp slipping.
3. Kinks and dog-legs.
4. Socketing.
5. Sheave equipment.

Lubrication

The need for proper lubrication of all mechanical equipment, including wire rope, is so self-evident that it seems almost an insult to the intelligence of the user to more than hint that its oversight is ruinous to the equipment. Yet by far the majority of oil field troubles are directly or indirectly due to lack of proper lubrication, so this subject must be considered if rope trouble is to be reduced. Even as the initial oil in a gas or steam engine or in an automobile or in any other kind of motive power unit cannot be expected to last any appreciable time after starting up, so the shop lubrication in a wire rope should not be counted on for any appreciable use after the periods of storage and installation of the rope.

Considering first the better non-corrosive conditions of rope use: Any stress on a rope compresses the core and uses up some of its impregnated oil; a combination of axial with bending stresses in a much larger measure diminishes the amount and efficiency of the lubrication; combine with these a high rate of speed as in the rotary drilling, together with the enormous crushing and external grinding of multiple layer winding and some idea of the necessity of both external and internal lubrication is seen.

Fig. 3. High Strand.

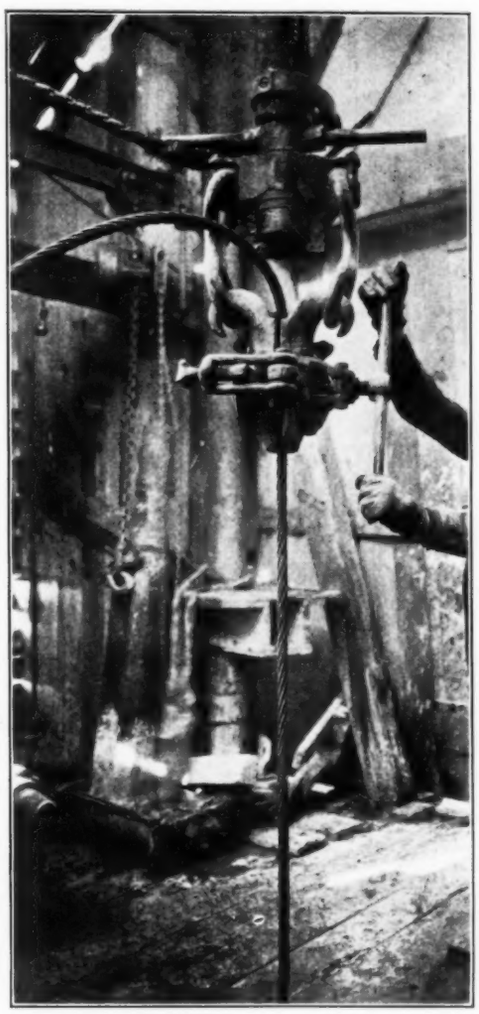

Fig. 2. Slipping line through clamps.

Fig. 4. "Slip Cracks."

The life of the rope is more dependent upon the life of the core than upon any one other element, and thus it is of prime importance to properly preserve and lubricate this core. Still there are those who will insist upon assuming that the oil initially put into the core is an ever-present reservoir. The heavier the axial load, the smaller the bend over sheaves, or the higher the speed, then the greater deterioration of the core through chafing and compression and the greater the need and frequency of lubrication.

Rope service varies approximately inversely as the square of the speed, other conditions being equal, so that high speed operation of rope requires lubrication service in that ratio.

Rope service, due to bending over sheaves, does not vary in direct proportion to sheave diameters but reduces about 1½ times faster than the reduction of sheave diameters so that there is a greater rela-

[1] Union Wire Rope Corp.

tive demand for lubrication with smaller sheaves.

Considering now the effect on the rope from corrosion alone: A rope in storage will undergo certain losses in volatilized lubrication and consequent "setting" of the rope to the spooled curvature of the rope. Condensed moisture from the atmosphere, even where the rope is kept covered, will seep into the rope in time starting the action of corrosion. If left out in the weather, this action will take place many times faster. After the rope has been down the hole, the nature of the fluid will determine the rapidity of the consequent corrosion and deterioration as some fluids may be strongly saline, or even acidulated, causing rapid decay of the hemp core as well as corrosion of the steel wires. The rust from the wires acts as a sharp abrasive on the hemp fibres of the core, which in operation results in a decided chafing of the core.

Rust causes an internal binding of the rope structure resulting in a decrease in elasticity of the rope as well as a loss in the ability of the strands to adjust themselves to proportionately carry the loads applied to the rope. Consequently there are frequent failures of the rope by individual wires "wickering," by single whole strands failing (as in Fig. 1), or by the complete failure of the whole rope, and any of these failures from such jerks or shock loads as would not so affect a well lubricated rope.

Taking into consideration a combination of all the conditions mentioned above, it will be seen why it was stated that the majority of rope complaints are traceable directly or indirectly to lack of lubrication. The questions of how often to lubricate, what lubricant to use and how to apply the lubricant in the field have been so well covered by articles recently published in petroleum periodicals that they do not require discussion here.

Fig. 5.

Fig. 7.

Clamp Slipping

On page 86 of "Reprint of Group Session from Eighth Annual Meeting Bulletin" of the A. P. I. (1927), there is a "Rope Manufacturers' Sub-Committee Report on Clamp Slippings" which so fully covers the rope abuses from clamp slipping that it is copied here verbatim:

"The present trend in cable tool drilling to greater depths is bringing about a critical condition that has not to date been thoroughly analyzed. Heavier tools, along with deeper holes, has more than doubled the static tension which is still held by the same primitive clamp of the same length as on the shallow holes, which requires correspondingly greater pressure to hold the drill line without slipping. The result of this heavier pressure is a distortion of the rope except in the case of perfectly fitted slips. Any undue wear of the slips from any cause will magnify the distortion of the rope. It will be appreciated, with the heavier tension on the rope, that the clamping pressure will be great enough to compress the rope below its manufactured diameter or that corresponding to the tension under which it works; that is, the diameter of the rope above the clamp is considerably greater than within the clamp. In other words, equilibrium against slippage is maintained by the pressure within the clamp and the enlarged diameter above. The margin by which this condition is maintained is extremely small; therefore it is not difficult to visualize what happens when a slight release in pressure is made to allow slipping, namely, the first movement of rope concentrates the abuse on the enlarged diameter just entering the clamp which must almost instantly conform to the reduced diameter in the clamp coupled with the tension below it.

"The heat effect of the slippage may readily be calculated knowing the rate of slipping and the load or tension. If the exposed surface of the rope corresponded to a solid round bar of the same diameter the peripheral contact surface would be great enough to dissipate the heat. This, however, is not the case with a rope as it only has six minute surfaces of contact along the crowns of each strand, causing sufficient intensity of pressure to generate excessive heat. This hardens the wire and makes it brittle. This explains the appearance of cracked wires at an early stage in the use of a line.

"Considering another phase of this slippage, namely, the driller is trying to pull through the clamp a rope which is approximately 1/16 of an inch larger than the opening of the clamps. This contraction cannot take place without a lengthening of the lay and this excess twist is crowded into the rope above the clamp, causing the strands to become loose on the center.

"Now, considering the case of elliptical slips under the above condition; this will cause high or drawn strands (Fig. 3) when this portion of the rope is later forced through the clamp. The ultimate position of these high or drawn strands finally concentrate at considerable distance from the point of original abuse. Experiments have shown that damage causing high or low strands will result in the damaged section ultimately adjusting itself at times as far as 1,000 feet away from the original point of abuse as drilling operations proceed.

"The practice of slipping the clamps when the liners are too small size is generally indicated by parallel wear or broken wire on opposite sides of the rope. (Fig. 4).

"The vicious practice of slipping the rope through the clamp in cable-tool drilling in place of turning down the temper screw is largely the result of failure to improve methods of feeding out the rope into

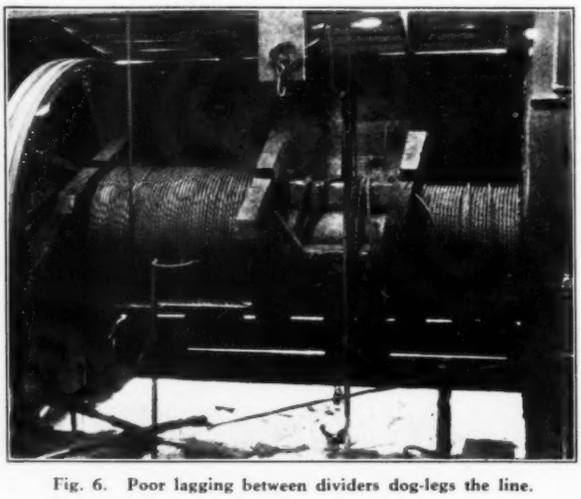

Fig. 6. Poor lagging between dividers dog-legs the line.

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the hole. Drillers have adopted the slipping expedient in order to increase the speed of drilling. It is the unanimous recommendation of the Rope Manufacturers' Sub-Committee that improved methods of rope feed be devised that will eliminate this practice which has ruined more drill lines than any other single form of abuse, and until such improved clamp is developed, the Manufacturers' Sub-Committee strongly recommends the discontinuance of all clamp-slipping in drilling operations."

Fig. 2 shows this practice of clamp slipping and Figs. 3 and 4 two of the results from this practice by which thousands of feet of rope annually are ruined. The condition shown in Fig. 4 does not necessarily show up immediately, but develops with subsequent use of the line.

Fig. 8.

Kinks and Dog-Legs

The majority of kinks or dog-legs are caused in the handling or by the equipment. Such distortion of the rope cannot be removed and causes a local spot subject to excessive wear and to a decrease in actual strength of rope, frequently causing rope failure as in Fig. 5.

When unspooling a rope, do not pull the rope off over the side of the reel, but mount the reel on a horizontal shaft or pipe supported by blocking or by jacks. Take the rope off from the under side of the reel so that, should the reel run ahead of the rope, the slack rope will lay back on the ground with less tendency to loop up than when the rope would pile up in front of the reel, should it be taken from the top of the reel.

Dividers, where the rope has a pass around sharp edges in the slots or over bolts, cause dog-legs. So does uneven lagging between dividers. These faults are shown in Fig 6, resulting in the condition shown in Fig. 7.

If the girt hook, through being weighted too heavily, pulls the slack rope too far from the clamp there are liable to be two dog-legs, one at the hook and one over the clamp. The latter is particularly dangerous as it does not allow the rope to enter the clamp with any degree of uniform strand tensions, and when "slipping" high strands are frequently started resulting in the condition shown in Fig. 3.

Socketing

Improper socketing, such as is shown in Fig. 8, very frequently results in high strands seen in Fig. 3. It is practically impossible with such a practice to get uniform strand tensions. The proper method is shown in Fig. 9.

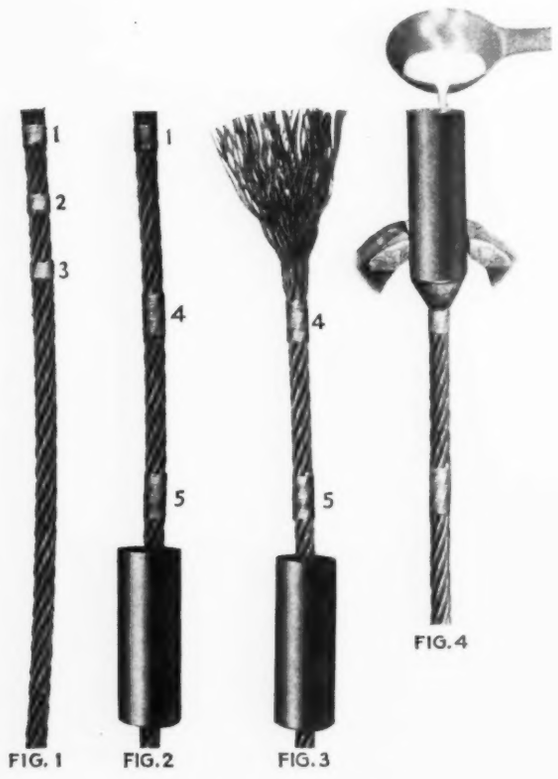

Fig. 9. SOCKETING A MANDREL.

Fig. 1. Shows a driller just cut, having three proper tie wires.
Fig. 2. Put on two additional tie wires, one 16 inches from end and the other at a distance equal to length of mandrel. Remove second and third tie wires.

Fig. 3. Slip the mandrel over the rope. Remove the end tie wire; cut out the hemp center; mule tail the wires. Wipe grease from the wires.

Fig. 4. Slip mandrel over the mule tail until the wires are flush with the top of the mandrel. Set the rope vertically in a vise; seal the bottom of the mandrel with clay or like material; pour in zinc (not babbitt or lead).

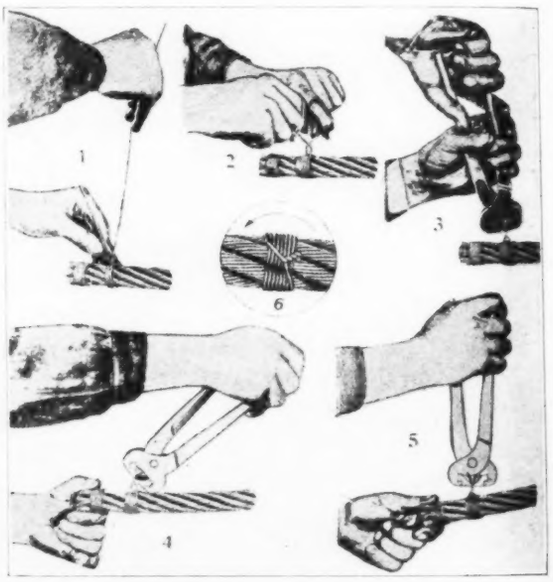

Fig. 10. PUTTING A SEIZING ON A WIRE ROPE.

(From U. S. Government Master Specification No. 297.)
(1) Wind the seizing wire on the rope by hand, keeping the coils together and considerable tension on the wire. (2) Twist the ends of the wire together counter-clockwise by hand, so that the twisted portion of the wires is near the middle of the seizing. (3) Using "Carew" cutters, tighten the twist just enough to take up the slack. Do not try to tighten the seizing by twisting. (4) Tighten the seizing by prying the twist away from the axis of the rope with the cutters. (5) Tighten the twist again as in (3). Repeat (4) and (5) as often as is necessary to make the seizing tight. Cut off the ends of the wires and pound the twist flat against the rope. (6) The appearance of the finished seizing.

Note: When a rope is to be cut, six seizings, or tie wires, are to be placed on the rope so that three of these will be on each side of the place where the rope is to be cut.

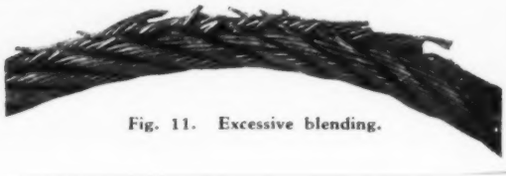

Fig. 11. Excessive blending.

Safety *in* Pipe Line Construction

By ALBERT W. BREELAND
Safety Supervisor Lone Star Gas Company, Dallas, Texas

IN preparing an article on the subject "Safety in Pipe Line Construction" one does not have a wealth of information collected from long years of experience from which to draw for assistance, for such information on safety activities in pipe line construction does not exist. It is only during the past few years that any organized effort has been made to control accidents in the pipe line industry and this has been done principally by the larger companies. Today, however, the list of companies in the oil and gas industry which are actively engaged in accident prevention work is constantly growing.

In this article I shall discuss certain phases of the subject which, no doubt, are so obvious to some of you that you may question the advisability of including them, but unfortunately, not all of the companies in the industry have made, as yet, any organized effort to prevent accidents. For this reason it was deemed advisable to attempt to cover every piece of equipment and each operation that would be most likely to cause an accident. Although this paper will deal principally with welded pipe lines, the general principles apply to all pipe lines.

Organization

Accident prevention work in modern pipe line construction, not unlike modern pipe line construction itself, must be well organized and properly executed to be effective. To begin with, the management must be thoroughly convinced that accident prevention pays substantial dividends, not only from a humanitarian, but also from a financial standpoint and must give its unqualified support in the work.

Next in line, I should say, is the safety supervisor, who must be honest, sincere, and enthusiastic about the work. I might elaborate upon the safety man's qualifications even to the extent of several pages, but I do not believe they can be covered more fully than in these three words: honesty, sincerity and enthusiasm.

If any degree of success is to be attained in accident prevention work, the superintendent must believe in safety. He must not only believe in it, but by his actions, he must let his attitude be known to his subordinates. He must insist on all reasonable safeguards being installed and all reasonable safety suggestions being complied with. When a superintendent is so interested in accident prevention work his attitude will invariably be reflected in the conduct of his subordinates; for this reason his support is of utmost importance in accident prevention work. Without his unqualified support our task will be much harder.

Next to the superintendent is the foreman. Many safety men and executives are fully convinced that the foreman is the man upon whose shoulders rests the greatest responsibility for controlling accidents as it is the foreman who directs the individual efforts of the men. Safety rules and regulations are useless if not enforced and it is the foreman who must see that these rules are enforced. In my company our foremen are taught that accident prevention work is just as much a part of their job as laying and operating

Pipe line scene in the Texas Panhandle.

View showing guard preventing tractor from tilting backward.

pipe lines and I am glad to say that without exception they treat it as such.

In selecting the workers or the man-power for the organization we have another problem to solve. If a physical examination of all men is made the problem is greatly simplified, particularly so since the important, although laborious, task of selecting men is not left up to the superintendent or foreman, who are not qualified to pass upon a man's physical fitness for any particular work except from appearance, but to the examining physician. It is among the workers that 99 per cent of accidents occur and it is for this reason I cannot stress too strongly the importance of a thorough physical examination of all men engaged in pipe line construction. In my company we have been examining men only about nine months and although that is not a very long period from which to draw conclusions, from our experience during that time, I am thoroughly convinced that a physical examination of all employes is a financial success. This is true not only from the standpoint of reducing the accident potential by eliminating men who are physically unfit for such work; but also from the standpoint of increased efficiency, resulting from the employment of men who are physically suited for such work.

We have no definite age limit, but depend on the judgment of the doctor as to whether or not the man is qualified for the job. We believe that many men at forty-five or fifty are more physically able bodied than others at thirty or thirty-five. It is for this reason that we have left the age limit of each man to the judgment of the doctor.

In our organization approximately 25 per cent of all men examined have been rejected.

In examining men, we believe it more satisfactory to have the examinations made by our own staff physician rather than by local private physicians for several reasons, some of which are as follows:

The Company physician is more likely to give a thorough examination than the local physician. From his contact with the oil and gas industry he usually has a better knowledge of what the physical requirements are, and he is not subjected to the temptation of being lenient with the local men, many of whom the local doctor, no doubt, serves as family physician.

Furthermore, the company physician is nearly always on hand to render first aid and care for the injured when an accident occurs. By having our doctor on the job, we have eliminated many small doctor and medical bills.

The qualifications of a physician for this type of work, in addition to his training and experience, should be—honesty, sincerity, sympathy, enthusiasm and a good knowledge of human nature. We feel that the success of our own physician has been due in a large measure to his ability to get and maintain the confidence of the foremen and workmen.

Equipment

In modern pipe line construction the motor truck plays one of the most important parts. It is used for stringing pipe, hauling material necessary for pipe line construction, and for the transportation of men to and from work. There are certain hazards connected with the transportation of pipe and other materials with which we are very well acquainted. The majority of these, however, are due to the human element rather than to the failure of equipment or to the lack of proper safeguards and will be discussed elsewhere in this paper. It is in the transportation of men to and from the job that our greatest hazard exists. Picture, if you please, a truck with a platform body going along the highway or over rough roads with thirty or forty men sitting on the bed with feet and legs hanging over the sides and end and it will not be very difficult for you to imagine what could happen if a passing car should get too near or should skid into the side of the truck or if the truck bounces over rough spots at a fairly good speed. What chance has a man to protect himself under such circumstances? None. We have learned from bitter experience what can result from such an unsafe method of transportation of employes. To overcome this hazard we built a frame truck body approximately 4½ feet high, with an end gate of the same height, boomed at the top and about 12 inches from the bottom with two steel chains, very similar to those used in booming pipe. This frame, better known as the "bull pen", is collapsible and is easily removed when the truck is needed for hauling material that cannot be conveniently handled with this type body. To load and unload the men, the end gate is removed. When the first body was installed it was pointed out by some of our men that it would greatly decrease the utility of the truck, but on the contrary, it was found that for practically all material with the exception of pipe, it greatly increased the utility and load efficiency of the truck. On welded lines I have seen a truck with a normal load of oxygen and acetylene bottles topped off with a load of hay and feed stuff for the skinners' teams or a load of rubber for making fire bends; sometimes both. The results have been so gratifying that practically all trucks used in this class of work are now equipped with this type of body. Before these bodies were installed accidents were common occurrences and during the past two years two accidents, both resulting from cars and trucks being sideswiped forcefully impressed upon us the need of a remedy. One of the accidents cost the man the use of both legs and

Tractor equipped with guard in normal position.

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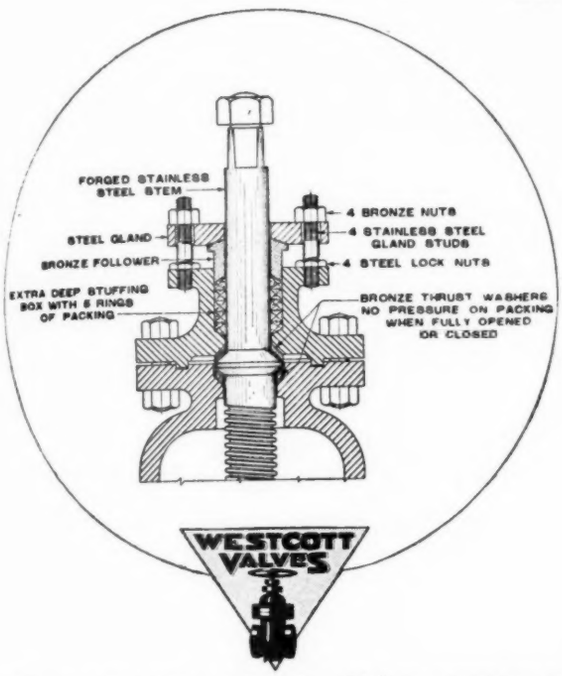
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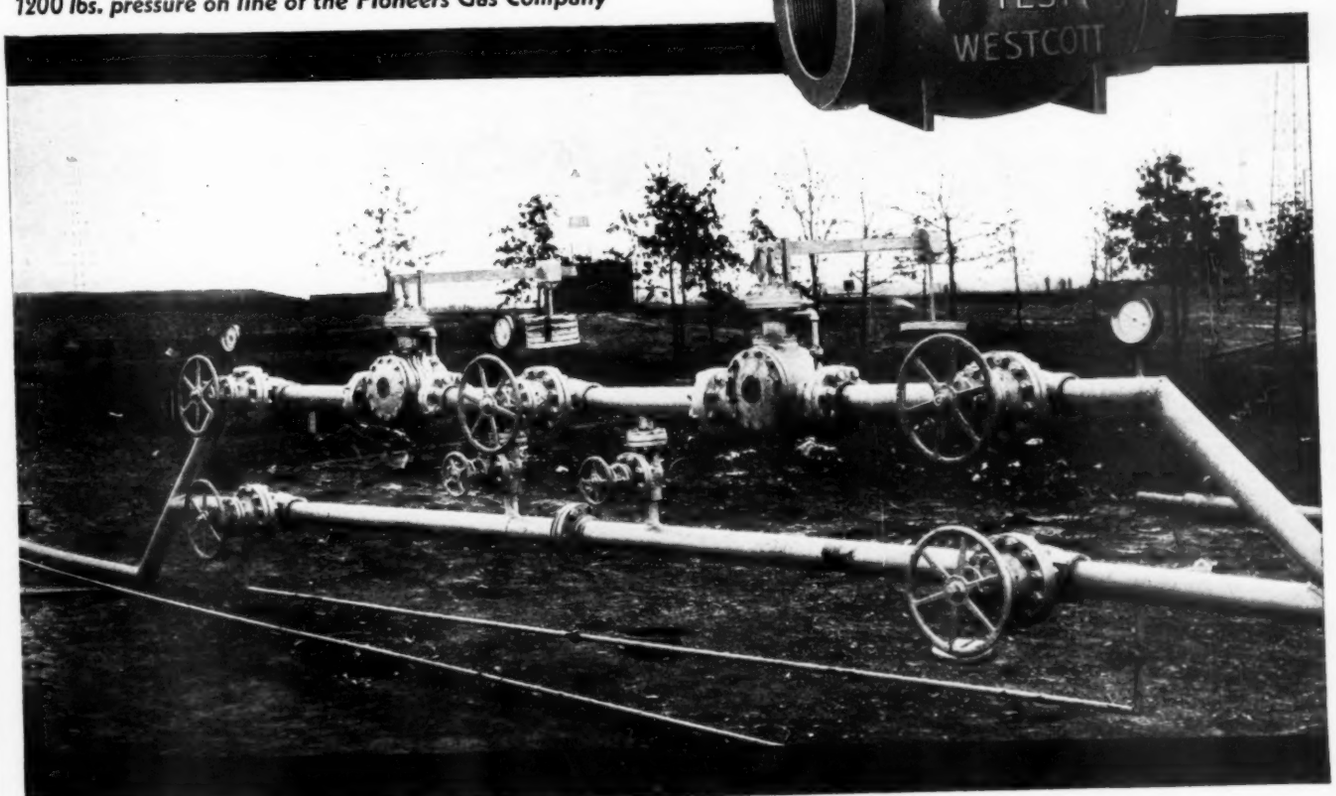

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Truck equipped with "bull pen" frame used to transport workmen and materials.

practically the loss of his mind, while the other cost the injured the loss of one leg just below the thigh. I am glad to say that accidents from this source have been practically eliminated.

A very important piece of equipment in pipe line construction is the tractor. A possible danger in the use of the light type tractor is from kicking over or bucking when the motor is run too rapidly in changing from high to low gear while making a hard pull up an incline or occasionally on level ground. To eliminate this hazard an outrigger or guard was designed which prevents the tractor from reaching the overbalancing point. It was claimed by some critics that this device would prevent a tractor from going up steep inclines or crossing wide ditches, as the tail would drag when the front wheels were approximately 24 inches above the level of the rear wheels, but climbing steep inclines is one practice we try to avoid and this device greatly aids in preventing it. Two fatalities resulted from the drivers attempting to drive their tractors up short steep inclines. As to crossing wide ditches, this occurs so infrequently that the loss of efficiency is practically negligible. We believe that with the aid of this guard, we shall have no more accidents from this source.

During the last two years, however, we have purchased only the heavy type tractor. We have found this type of equipment to be far superior to the lighter type equipment for pipe line construction.

Air compressors play a very important part in pipe line construction since they are used in testing the line before it is placed in the ditch and in drilling rock for blasting. Very fortunately, compressors of standard manufacture are built to standard codes and defective equipment is rare. All receiving tanks on compressors should be equipped with safety valves, adjusted to pop in sufficient time to still leave a good factor of safety. All equipment such as stop cocks, connections, and hose should be of such quality as to handle the required pressure safely.

Probably the most important equipment as far as pipe line construction is concerned is the ditching machine, without which laying a pipe line would be a very slow and expensive proposition. The hazards connected with this important machine are relatively few; at least, our experience has proven so, and it is, therefore, given little space in this paper. I will add, however, that the life of some of the moving parts of the machinery could be materially lengthened by being completely enclosed in metal guards which would also eliminate practically the only existing hazards in connection with this equipment. In addition to the machinery it is also necessary to have a large supply of picks, shovels, sledges, hammers, rock drills, and various other small tools, all of which should be kept in first-class condition. A well-equipped blacksmith shop should be on the job to keep such tools in repair. Very few serious accidents result from the use of good hand tools.

Actual Construction

Next, we shall discuss the actual work. The first work to be done after the survey has been made is clearing the right-of-way. While the average person does not associate very many hazards with this part of the work, there are a number of hazards peculiar to this operation which should be considered. First of all, is the danger of ivy poisoning, especially in the spring and summer, and I might say here that we have had several cases, some of which disabled the victims for weeks. Practically the only safeguard against this hazard is to caution the men to handle all ivy or vines of a similar variety in such a manner that the vines will not come in contact with the naked skin. This does not always prevent the poison, however, as some men can walk through the forest and get it. Some of our men have tried a serum which is supposed to render a man immune from this poison. This was not successful in all cases. Then, there is the danger of reptile and insect bites and as most of you are, no doubt, aware the bite of a certain domestic reptile is quite potent. Very fortunately, we have not, as yet, had an employe to receive a rattlesnake bite. The wearing of good boots and keen observation are about the only safeguards that can be applied against this hazard. All of our first aid kits are supplied with snake bite outfits.

Cutting and falling timber is another hazard in connection with clearing right-of-way which must be given careful attention. The foreman or man in charge of this work must have a good knowledge of the methods employed to throw large timber. Men cutting small timber with axes should be spaced so that there will be no danger of injury from falling trees or from a fellow workman's axe. It is here, as elsewhere, that the foreman can play a most important part in accident prevention work. In certain localities where timber is not deep rooted, perhaps a safer method of falling large timber would be by blasting. The danger of being trapped by falling timber would be eliminated as the men would be able to get out of danger before the charge went off. Furthermore, it is much easier to cut a large tree lying in a horizontal position than in a vertical one.

In blasting stumps on the right-of-way, there are several hazards; one of which is the danger of injury from falling stumps and rocks. Another hazard is premature firing; this, however, is very remote. Possibly the greatest danger connected with blasting stumps is from improper crimping of the caps on the fuse. Men have been known to be so lacking in forethought as to crimp dynamite caps with their teeth. Men have been known to crimp caps by tapping

Dangerous method of transporting workmen.

with a hammer. Such men are not permitted on our jobs. Caps should be crimped with an approved dynamite cap crimper. We have been assured by the different powder companies that crimping dynamite caps with the proper crimper is safe. One way to eliminate this particular hazard is to use electric caps and a blasting machine instead of the old fuse and cap method.

Next in order of the work is stringing pipe. Of course, in order to string pipe economically, as well as safely, it is essential to have good equipment; however, the first and most important factor is the man who sits behind the steering wheel. In stringing pipe, it is necessary to exercise a greater degree of skill than in ordinary truck driving, particularly so since in many instances it is necessary to travel over highways on which traffic is heavy and the hazards connected with a long coupled trailer on a truck are greater than on an ordinary truck.

Trucks and trailers are designed to carry definite loads safely and should not be loaded beyond this factor of safety. Loads should be properly boomed; our practice is to boom both at the front and rear bolsters. On loads the tops of which are flat, we boom on top of the load; but on loads the tops of which are round or cone-shaped, we boom on the sides of the loads. When preparing to unload, our drivers are taught to release the boom standing on the ground and push the boom from them. By releasing the boom in this manner the possibility of an injury from the boom kicking forward with force is obviated.

In rolling the pipe from the truck the men should always stand behind the end of the joint and roll the pipe from them. The pipe should be dropped on the ground so that both ends will strike the ground at approximately the same time. Following in logical order in welded pipe line construction is lining up the joints for welding. There is one hazard in lining up on which it is well to lay particular stress and that is the danger of mashing or amputation of fingers of back end men when a joint is driven home. The back end man should be exceedingly careful not to attempt to remove dirt or other foreign bodies from the ends of the joints while forward joint is being driven home. Many a finger has been left in the pipe and many a badly mashed hand has resulted from this practice. The men should also be exceedingly careful to stay out of the reach of the swinging tongs as the lining up tractor moves forward.

In actual acetylene welding where there is no gas in the pipe, about the only hazard that we have encountered is injury to the eyes of welders who for some reason or other were not wearing goggles. Such injuries, however, are exceedingly rare as all of our welders wear goggles almost constantly. Where acetylene is generated on the job, smoking should not be permitted near the generators, especially while draining and recharging. When welding on lines through which gas or oil has been passed there is a fire and explosive hazard which will be discussed later.

Probably one of the most dangerous operations in pipe line construction is testing for leaks while the pipe is in sections. The sections range from 100 feet to 300 feet, depending on the size of the pipe and topography of country through which the line is being laid. As mentioned previously, pressure is furnished by portable air compressors operated by gasoline engines. First, each end of the section is plugged with testing caps which are made by welding a circular plate to a center ring. Into this cap is welded a nipple through which the air is admitted. This cap is fastened to the end of the pipe with followers and bolts. A ⅝-inch welded chain is then placed over the end of the plug and twice around the pipe with a double claw hitch and the two ends of the chain are fastened together with a load binder. The required pressure is then put on the sections. As soon as the required pressure is reached, the stop cock is closed and the welds and seams tested. With the plugs secured as mentioned above, they should not slip or give with the pressure usually applied, however, all workmen should be cautioned not to stand in front of the plugs while pressure is on the sections. In fact, they should not be permitted in front of the plugs while pressure is on the sections. Sometimes the cap is very tight on the end of the pipe and it is difficult to remove and it has been reported to me that some testing crews relieve the boom chain and allow the cap to blow off. This is a very dangerous practice and should not be tolerated. Testing is another operation in which the human element plays a large part in controlling accidents. It is work that requires constant supervision.

Painting or applying protective coatings present very few hazards. The only trouble we have ever experienced was in warm weather when the painters' faces and hands would blister and peel off. This trouble is not serious and can be prevented by using cold cream or vaseline on the face and gloves on the hands while handling the paint.

In handling a hot application there is danger of burns from splashing and spilling the hot paint. To overcome this the crew, consisting usually of one man pouring, two men swabbing and one man handling the pot, should wear asbestos or oilcloth pants, boots, gloves, and goggles.

In ditching and excavating, as mentioned previously, about the only hazard in connection with ditching machines is the unguarded gears. We have not installed guards on our machines as yet, but personally I think it should be done and believe that it will be only a matter of time. However, we have only had one lost-time accident from this source in three years and only seven days were lost from this one.

Unfortunately, however, not all the ditch can be cut with the machine. In creek and river crossings, in railway and highway crossings and other deep cuts it is necessary to cut the ditch by hand. In hand ditching there are several hazards which should be given careful consideration. In all hand ditching, men should be spaced so that there will be no danger of injury from each others tools. All ditches for creek crossings and cuts, where there is the slightest possibility of a cave-in, should be cribbed to prevent men from being injured from the ditch caving. It would be entirely out of question for me to say that all ditches beyond a certain depth should be cribbed. This should be left up to the judgment of the foreman, because any man who has had a good deal of experience in ditching and excavating work should be able to determine from the conditions prevailing at any particular location just when cribbing should be done. This, of course, requires close supervision and inspection.

In deep ditches it is also important to see that no large rocks, stumps and other heavy bodies are permitted to remain where they would be likely to fall on men in the ditch.

Possibly the greatest hazard in connection with hand ditching is in blasting rock. The old method was to drill the holes, place the charges, light as many fuses as the powder "monkey" could light, and still have time to get in the clear before the first shot went off. Right here is where one of the hazards existed. The powder "monkey" did not always calculate his time correctly and the charges commenced to go off before he was in the clear. Then there was no way to determine whether all the charges had gone off except by counting, and occasionally a miscount was made with disastrous results. One of our shooters went back to the ditch to investigate after he was supposed to have counted all the charges, and just as he was about over the ditch a charge went off. He managed to

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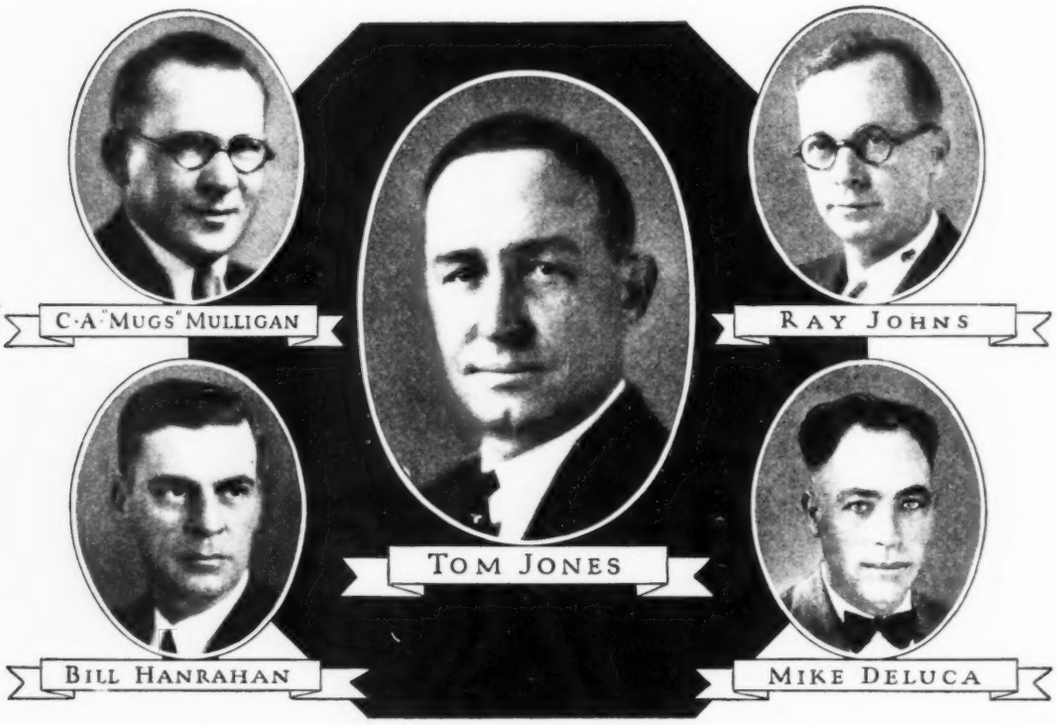

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pull through with his life, but lost one eye. In another instance, a shooter lost both eyes because he deliberately disregarded all caution and went back to the ditch to light a fuse which he thought had gone out or had not been lighted, before the charges commenced going off. With the old hand-firing method there was also the danger of some outsider or animal walking up about the time the time the charge was ready to go off.

There was also the danger of a charge which had failed to go off being exploded by contact with a workman's pick or the ditcher or rock excavating machine. With the modern method these hazards have been eliminated. All the charges go off simultaneously and the fire can be held until everybody is in the clear. After the charge has been exploded, with the aid of a small instrument known as a galvanometer, any wire that is not entirely clear or in any way looks suspicious can be tested to determine if the charge failed to go off. If the instrument shows a circuit the charge has failed to go off and can be reconnected to the blasting machine and fired as in the beginning. I might add that during the nine months that we have been blasting by this method we have had very few instances where all the charges failed to go off at one time. I might also add that since we commenced using the machine method of blasting we have had no accidents from this source. In addition to being a safer method of blasting, we have found it to be more efficient and more economical than the old method.

With the fuse-and-cap method of blasting there is the hazard of crimping caps, as previously mentioned. Many men have lost their lives from improper crimping of caps and many children have lost their lives or were maimed for life as a result of playing with dynamite caps. With the new, or machine method, of blasting, this hazard is eliminated, as the blasting caps are attached to the wire in the factory by skilled workmen.

We encounter our next hazard in laying and lowering the pipe in the ditch. If the equipment is suitable for the size pipe being handled and proper supervision is exercised, accidents from this operation should be practically negligible, but we do not always have this almost perfect combination. I think the greatest hazard from lowering-in is the failure to provide sufficient safety skids for protection of men who are required to get under the pipe to retouch the painting or protective coating, to clean out caved ditches, to make bell hole or connecting walls, etc., before the pipe is lowered. There should not only be a sufficient number of safety skids under the pipe, but they should also be made of timber that is not easily broken. These skids should be made of oak or other extremely tough wood, as pine and other soft or semi-soft woods will not stand the sudden strain to which the skids are subjected, especially when handling large-diameter pipe. We have had instances where one skid would suddenly break and all other skids for several hundred feet would snap, one after the other. Proper material and constant supervision should eliminate this hazard. The remainder of the job, backfilling and cleaning up, presents no hazards of any consequence and will not be given any space in this article.

While my article was only supposed to cover the hazards in pipe line construction, I do not believe it amiss to discuss briefly some of the hazards in connection with pipe line repairs. My company, in years past, has had some severe accidents while making repairs to main lines. In one instance one man lost his life and another sustained severe injuries, while in others we have had men injured more or less seriously. When making repairs to a line through which gas or oil has passed, there is the ever-present hazard from fire and explosion. This is especially true when it is necessary to replace a joint or section of pipe. The greatest problem we have had to solve was the best method to combat this hazard.

In the old days, before the development of modern methods and tools for cutting out a joint or a portion of joint, the cut was made with pipe-rippers and sledge-hammers. Cutting pipe by this method was not only a slow and laborious task, but it also presented two hazards: The danger of a spark from the blow of the hammer on the cutter igniting the gas vapors, and the danger of a chip of metal striking a man in the eye.

One of our engineers recently developed an improved portable cutter for cutting large-diameter pipe in the field. This apparatus, unlike all other cutters which are on the market, has four cutters. It is collapsible and is set up on the end of the joint of the section to be cut and two men can make a cut through 20-inch pipe in 15 minutes after it has been placed on the pipe and adjusted. Placing on the pipe and adjusting requires less than thirty minutes, or less than an hour is required for the complete operation. With this cutter it is not necessary to wait until the line has been completely drained to make the cut, and also it eliminates the two hazards mentioned above.

In making repairs to a line under pressure, in addition to the fire and explosive hazard and the danger of flying pieces of steel, there is also the danger of injury to the eyes from blowing of sand and gravel. We have had several injuries from this source, one of which was quite serious. About the only safeguard I can suggest against this hazard is to wear goggles and, as far as possible, to keep out of the path of the escaping gas.

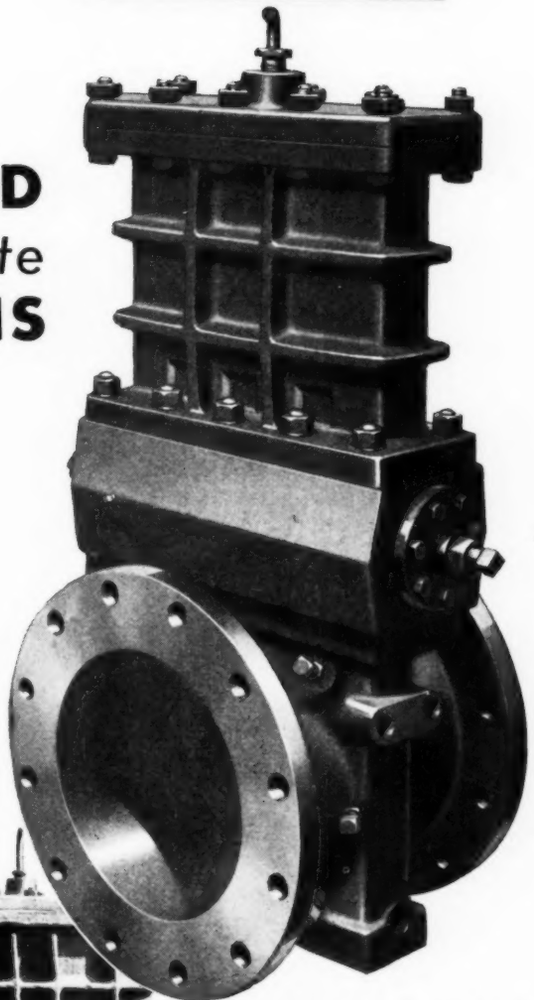
I believe my article would be incomplete without mention of one other hazard in connection with repairs to gas lines. That danger is failure to completely purge the line of air before putting it back into service. There is no definite formula for determining just when the line is completely purged, but a foreman experienced in pipe line operation will usually be able to determine from the size and length of line just how long it should be blown. Failure to thoroughly purge the line of air can result in serious consequences to the workmen as well as to the consumers affected by the shut-off.

You will note that throughout this article I have stressed the part played by the human element and the importance of the proper supervision of the work. Mechanical safeguards alone can prevent only a small percentage of all accidents; the vast majority can only be prevented through organized effort to reach every executive, superintendent, foreman and workman, and to have the full co-operation of every individual from the president of the concern to the men on the firing line. To this end we must concentrate our efforts.

O rapid in the past 10 years has been the expansion program of the natural gas industry that the demand has increased over $1,000,000,000,000 feet. In 1919 the then existing pipe lines delivered to domestic and industrial consumers 490,000,000,000 feet of gas. Over a period of the next 10 years great pipe line projects were built into new territories and in 1929 the consumption for both industrial and domestic purposes showed the demand had increased to 1,510,000,000,000 feet.

Economic students of the gas industry vision an increase almost if not as great during the next decade. One major gas line project was completed the latter part of 1929 as well as several smaller systems. The present year is witnessing the building of two other great transporting arteries and in all probability some of the plans for still other major pipe line projects will materialize to help swell the increase.

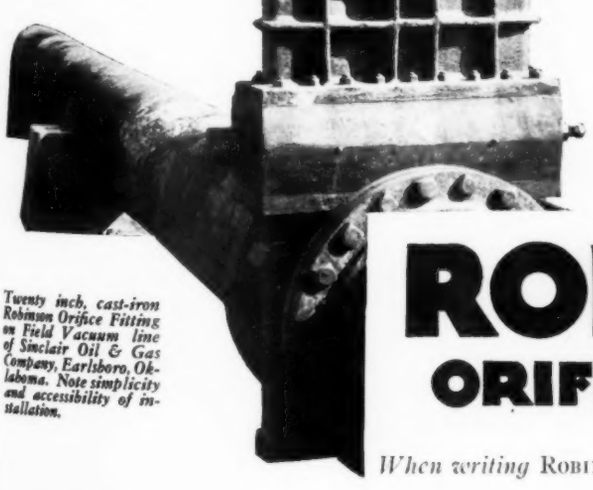
NO NEED FOR A BY-PASS



. . . . AND MORE *accurate* METERING IS ASSURED

You can eliminate the expensive and awkward old-style by-pass and increase your line efficiency by installing Robinson Orifice Fittings wherever gas, oil, air or water are measured by orifice meter.

The Robinson Orifice Fitting provides easy changing of plates, eliminating the old back-breaking method of extracting a plate between two flanges that had to be carefully separated. Frequent inspection and micrometer checking of the orifice diameter are made easier and quicker. More accurate metering is assured the Robinson way. The plate is so easily changed that there is no delay in adapting the meter to a changed flow condition. With the old style meter, the pens might ride off the chart a day or so before the meter man had time to change the plate.



Twenty inch, cast-iron Robinson Orifice Fitting on Field Vacuum line of Sinclair Oil & Gas Company, Earlsboro, Oklahoma. Note simplicity and accessibility of installation.

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The orifice of the Robinson Orifice Fitting is always centered in the line. In the old style meter the plate had to be very carefully inserted to prevent an off-center job. An error of as much as 5 per cent in the measurement can be caused by a plate that is not correctly installed. The entire Robinson Fitting occupies no more space than an ordinary gate valve and an ordinary pressure gauge—a great advantage over the old-style "hook-up." Can be mounted in almost any position, too.

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The Year's Progress in The Use of Grease for Lubrication

By R. R. MATTHEWS
Battenfield Grease & Oil Co.

MANY times we have been told the farmer is the backbone of the nation, and that in addition national prosperity depends on the prosperity of the farmer. Thus, when the farmer begins to increase grease consumption due to application of it to farm equipment, a significant step has been taken. Practically all cultivating, sowing and harvesting equipment for the farm is now equipped for lubrication with a grease gun, where the old oil can was formerly relied upon.

Machinery manufacturers have approached the realization that lubricating oil was being wasted in the best effort to properly lubricate certain bearings. Not only was oil wasted, but the service from the bearing was not as good as when grease was applied. This has led to liberal use on modern machinery of necessary fittings for grease lubrication.

Since the appearance in color of the remarkable well-fire photograph on the May front cover of The Petroleum Engineer, we have had so very many requests for enlargements that we are making it possible for everyone interested to obtain a beautiful reproduction, ready for framing, without cost or obligation. For details see advertisement on page 111 of this issue.

One of the problems which has caused lubricating engineers much study and plenty of grief is that of steel mill lubrication. This applies especially to the rolling mills. Most of those interested are familiar with force-feed lubrication, which has proven so valuable in increasing in many places the efficiency of lubricating oil. The same idea is now being applied to grease, and satisfactory progress is being made. It is understood that an installation is now in operation in a steel mill and is proving quite satisfactory. Heretofore greases of such high melting points have been necessary, and it was so difficult to apply them that the best lubrication was not always realized.

In the automotive field there is an increasing use of a special type gear. Manufacturers of this type of gear have made exhaustive tests to determine the best lubricant, and as a result are recommending a grease made using a lead soap. This same type of grease has also been found effective in producing quiet operation of the new four-speed transmissions, differentials, or both. This is another long credit mark for grease, since in the past most automobile manufacturers have recommended for this purpose a straight mineral oil reduced to what was considered the proper viscosity.

As has already been pointed out by others, the lead soap grease may be made in two ways: First, by making a soda soap and then replacing the soda with lead, generally derived from litharge; this gives the lead soap into which oil of proper character and consistency can be worked; second, by direct combination of the components. In this connection a clever kettle with the accessory apparatus has been worked out by an engineering company, with which it is understood the grease is made in one operation. This calls for thermostatic control and combination under pressure. Some manufacturers have made the soap base from a fish oil, while others have preferred the usual fatty oils. It now appears that the effectiveness of the grease is increased by a sulphur content somewhat in excess of that in the oil proper.

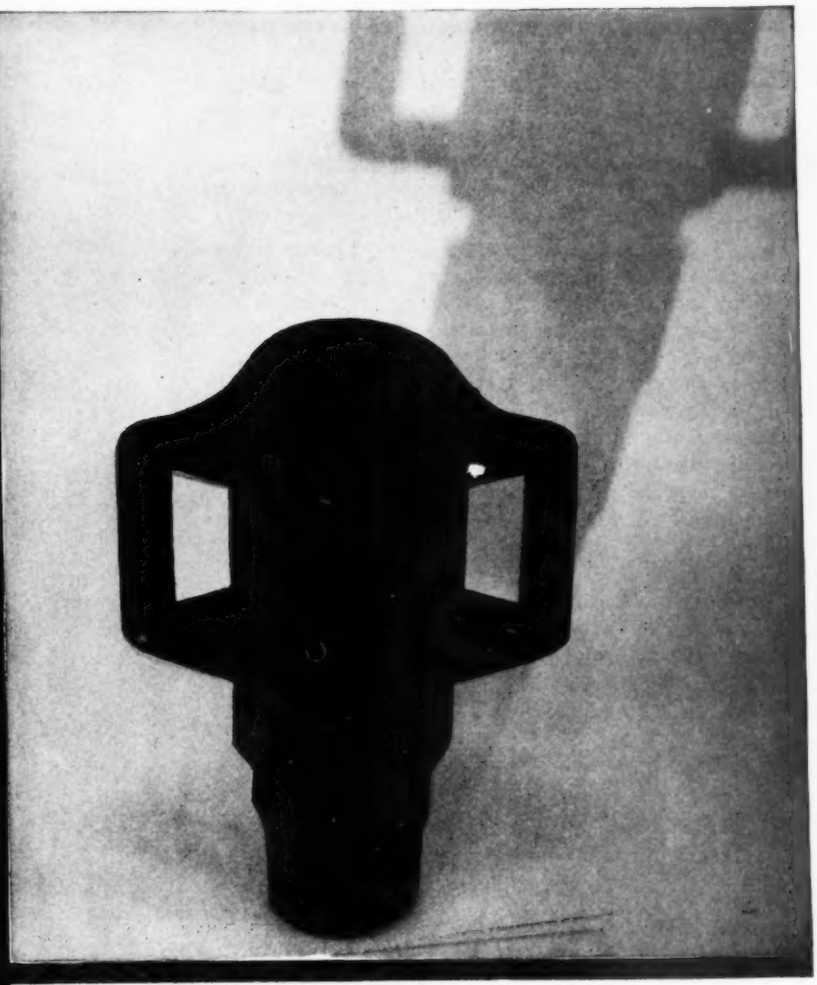
At the regional meeting of the American Society for Testing Materials in Detroit, Michigan, on March 19, H. C. Mougey, chief chemist of General Motors Corporation, presented a paper on "The Significant Properties of Automotive Lubricants." It was found that under certain conditions with certain types of rear axles, lubricants with a higher degree of so-called "oiliness" gave the best results. Actual tests were made, using a rear axle in the beginning of this work, and then an apparatus was developed which gave comparative results. Sulphur was found to contribute to this "oiliness" and with lubricants containing it there was no seizure.

Mougey reports in detail as follows: "With oils which have a viscosity of approximately 90 at 210° F. seizure will occur at about 7000 pounds per square inch if the lubricants are deficient in 'oiliness,' but with lubricants which have enough of this quality the bearing will carry the full 25,000 pounds per square inch without seizing. We have been able to prevent seizing with 'oily' oils as low in viscosity as 40 at 210° F., although if the oils do not possess this property of 'oiliness' seizure on our test machine has occurred in all cases before 25,000 pounds per square inch was reached, regardless of the viscosity, even though oils tested varied over the entire range of 40 at 210° F. to 300 at 210° F."

There is still more or less argument among grease manufacturers regarding the relative value of making grease using a pressure or an open kettle. One company which opened a new grease plant last year investigated this question very thoroughly. After getting all data which was available and carefully studying the matter from a theoretical and practical angle, a complete set of laboratory and semi-commercial experiments were carried on. This thorough work resulted in a decision to use open kettles. From the standpoint of economy, the arguments seemed largely in favor of open kettles. There was even some doubt whether the pressure kettle increased speed of operation, if the proper open kettle installation was made.

Another large company built a new grease plant and used pressure kettles. After operating a short time it was found necessary to increase production and more pressure kettles were put in. A company in the East has used pressure kettles for several years and is very much sold on them. They claim more complete saponification and a smoother, clearer grease than can be made with an open kettle. Use

The Positive Packing Unit



AXELSON Stuffing Box

This stuffing box, a result of constant improvement over a period of 25 years, is more widely used throughout the oil fields of the world than any other type. It is used at the top of a well above lead line to provide positive packing around the polished rod, preventing leakage of oil. The upper end of the cap has a reservoir to allow lubrication of the packing around the polished rod. Handles are integrally attached. The glands assure longer life. It can be used with any type of packing desired.

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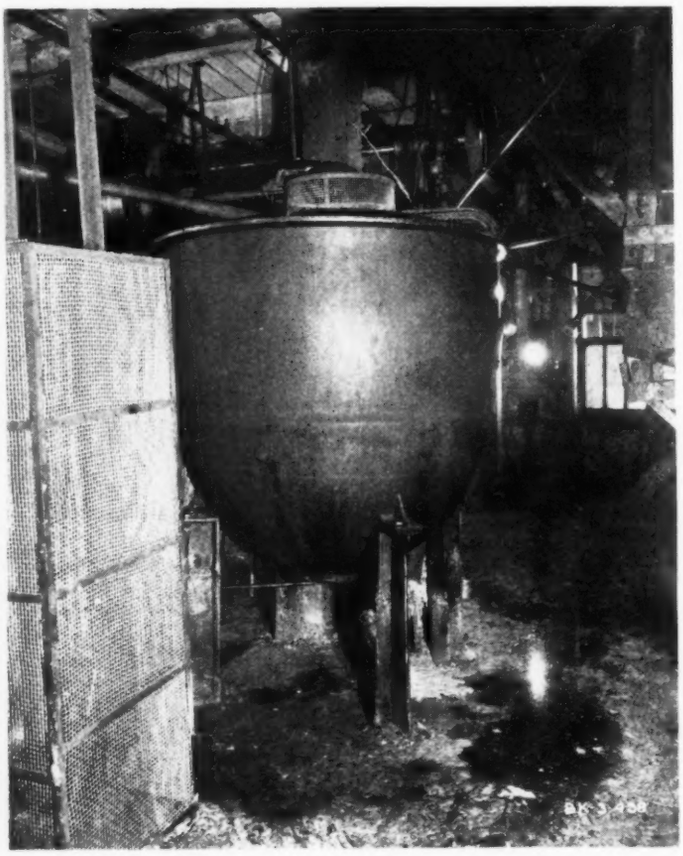
of temperature recording instruments has proven very helpful, regardless of the type of kettle.

Can-filling machines have been developed which are highly satisfactory where a run on one particular size is being made. Where a batch of grease is going into several different sizes of cans, it takes too long to make the necessary changes in the can-filling machine; consequently, a trained crew of men can really fill the cans quicker.

There has been a definite trend toward what is known as the full-friction lithographed can. This probably came about due to pressure gun grease being marketed in a friction top can, so that the metal disc with the filling hole could be put on top of the grease and would operate properly after the can was filled. If other greases were marketed in slip-cover cans it meant carrying two types of cans in some sizes, so most large retail marketers of grease have gone to the complete line of full-friction cans. The can is attractive in shape, lithographed well, and naturally is a tighter package than the slip-cover can. In fact, the only real criticism has been that the can is hard to open because the cover fits so snugly, but that may have been because a screwdriver, a coin or some other properly edged piece of metal which would slip under the edge of the cover was not used.



Grease kettle in a modern refinery.

Fibre board manufacturers have improved their product so that this type of case is now finding use for shipments of cans of grease. It has worked out especially well for the 25-pound can and appears to serve fairly well for the other size packages. It saves a little on initial cost, and also on freight where large shipments of grease are concerned; but care must be used in always protecting the cases from water. Many still prefer the almost certain protection provided by wooden cases.

Very little grease now moves out in wooden barrels, due in a measure to these four reasons: (1) Little additional cost of grease in steel drums over shipment in wood barrels; (2) no absorption of oil from the grease by the steel package; (3) the ease with which grease can be cleaned from steel of the drums; (4) softer greases are readily handled from steel drums with grease pumps, which appeals to those concerned with the handling of grease.

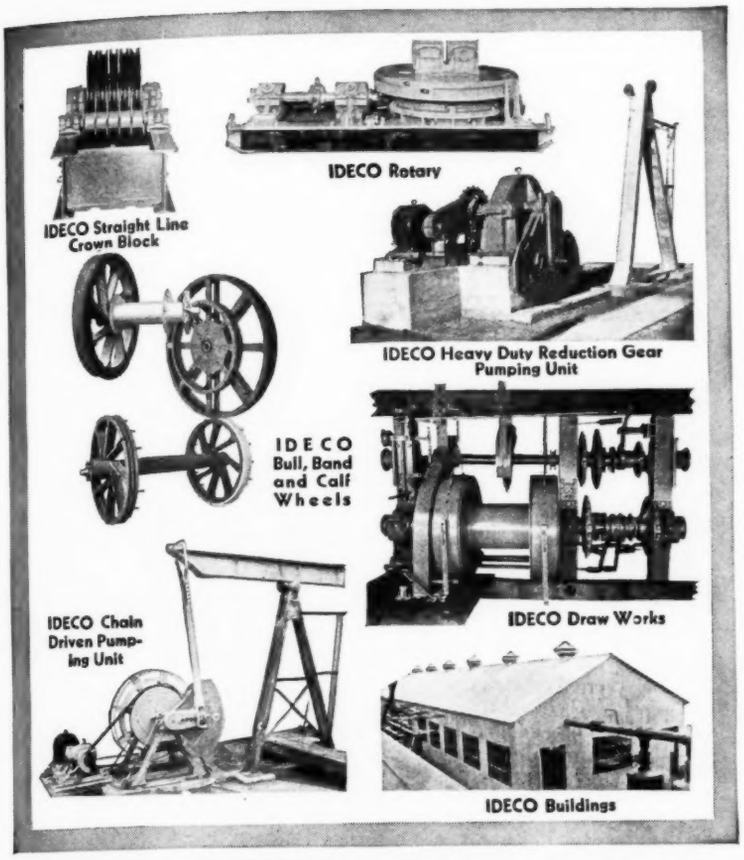
The drum which is most popular is the 15-gallon size, or what is commonly known as the 100-pound drum. One big reason for its popularity is the ease with which it can be handled where greasing service is offered. This is due largely to the development of the little truck which holds the drum, and the grease pump which fits on the drums and makes for easy, clean handling of the grease.

Those offering complete lubrication service for automobiles are beginning to realize that they are not living up to their obligation if they do not use special greases for certain parts of the automobile. Many have been offering universal joint grease to their customers for some time, but now are also putting in water pump and wheel bearing greases.

The water pump is a very important feature of any automobile, as a constant flow of plenty of cool water has an important bearing on efficient engine operation. The usual procedure is to give it a "shot" of pressure gun grease, but that grease has a very low resistance to the washing effect of warm water, consequently is soon washed off and the bearing is left without lubrication. Take a look at the average automobile a year or more old, and it will be found that the water pump is leaking because of wear due to lack of the use of the proper lubricant. A good water pump grease must first of all have a low solubility in warm water.

Wheel bearings may prove a real drag if they are not effectively lubricated. Pressure gun grease, which has often been used on them, will not stay put, and, most of all, it leaks out in a short time. Such leakage may get on the brake bands, and that means more trouble and expense. The consistency is of prime importance in a wheel bearing grease, and it should lubricate so there is no drag of the wheels.

These miscellaneous automobile greases are serviced in at least two ways: First, by making a separate charge for the particular grease which is applied; and second, by working out a price for a grease job which includes the use of all the greases. Naturally, such greasing service is only needed at long intervals, and between times the regular grease job will properly take care of the chassis, etc. • The aluminum stearate greases have met with popular favor, and increasing quantities are being sold and used. Their very attractive appearance indicates a quality that is not found lacking in the grease. In comparison with calcium or lime soap greases, four to six per cent less of soap is needed to produce a grease of comparative consistency. This means four to six per cent more of oil can be worked into the grease, and thus the lubricating value enhanced. This additional oil also increases the resistance to the washing effect of water, which makes the grease valuable as an auto chassis lubricant. Another important feature of the aluminum stearate type of grease is that there is no drying or so-called oxidizing of the grease. This means the grease passageways will never become clogged and the grease will always get into the bearing from the gun. Many "frozen" shackles come from the fact that the grease does not really travel in as it should. This grease is also having an increasing use as an industrial grease, due to having been found to be excellent for ball and roller bearings.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A Resume of » » » » Gasoline Manufacturing *by* Cracking

By Dr. GUSTAV EGLOFF, *Universal Oil Products Company*

Foreword

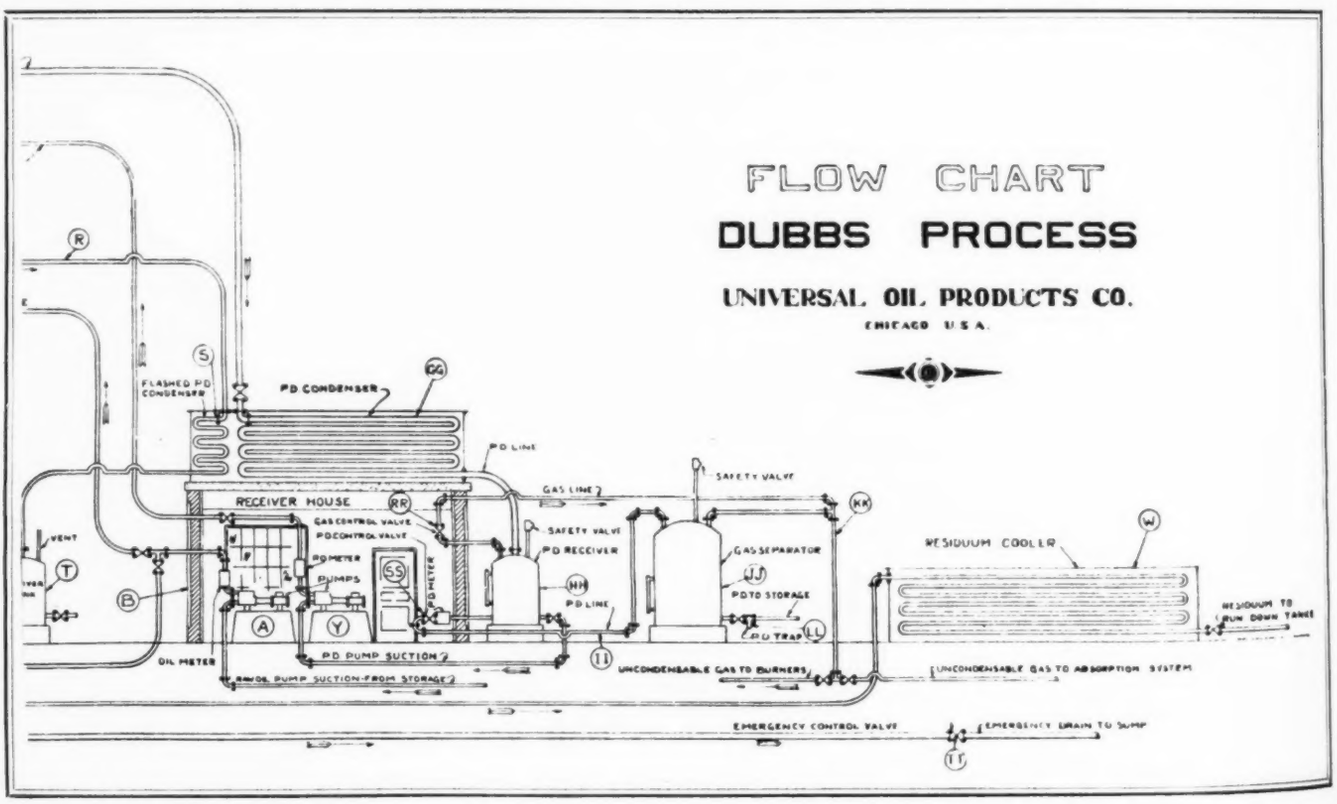
IN less than two decades the conversion of heavy oils has grown from an incident in the oil industry to a major refinery operation. Production of cracked gasoline, negligible in 1912, has gained at an astonishing rate until it now makes up more than a third of the estimated 20 billion gallons of motor fuel production in the United States for the year 1930. Because of its anti-knock properties, this type product holds place as premium motor fuel.

The amazing development of cracking has given to society other products than gasoline. These are Diesel or furnace oil, residual fuel oil, coke and gas. They are all finding their place in commerce. The increased use of Diesel engines and the extension of domestic oil heating furnish a ready market for cracked Diesel-furnace oil. The residuum produced fulfills market requirements for fuel oil. The coke product is used for electrodes in carbide manufacture, and as home and industrial fuel. And not least in importance, the gas from the cracking process, once considered by the refiner largely as a loss, now fills a unique place among petroleum products.

Those outside the petroleum industry probably do not realize the large amount of gas now produced by the cracking process and from the distillation of crude oil. It is estimated that during 1930 over 275 billion cubic feet of gas will be produced by the cracking process, and 270 billion cubic feet from crude oil distillation. The gas from these two sources is more than the country's entire production of manufactured gas. This petroleum gas is distinctive in its properties, being high in caloric value, which makes it valuable for enriching low fuel gases.

The importance of the cracking process as a source of gas is increasing and certain to grow in the future, for we are in a gas-consuming age. The cleanliness and flexibility of gas combustion gives this fuel signal advantages. It is estimated that over three trillion cubic feet of gas will be consumed in the United States during 1930. Of the gases making up this total, the one most used will be natural gas. The employment of natural gas is now five times as great as it was 20 years ago. This gas is being transported to users more than 800 miles from the sources of production, and a pipe line is proposed which will carry it 1000 miles. In 20 years the use of manufactured gas has quadrupled. Gas from the cracking process has increased in 18 years from a negligible amount to its present large production.

The trend toward gas combustion means better control of industrial operations and the increased well-being of city dwellers. It is estimated that smoke in our cities, due to the burning of coal, causes an annual loss in the United States of over five hundred million dollars. In some cities where dustfall has been scientifically measured it has been found to be as much as 500 to 1000 tons per square mile per year. The damage from this dirt is of several types. It increases expenditure for laundering and dry cleaning; it impairs metal work, paint and the surfaces of buildings; it adds to the labor of housekeeping, and causes an incal-



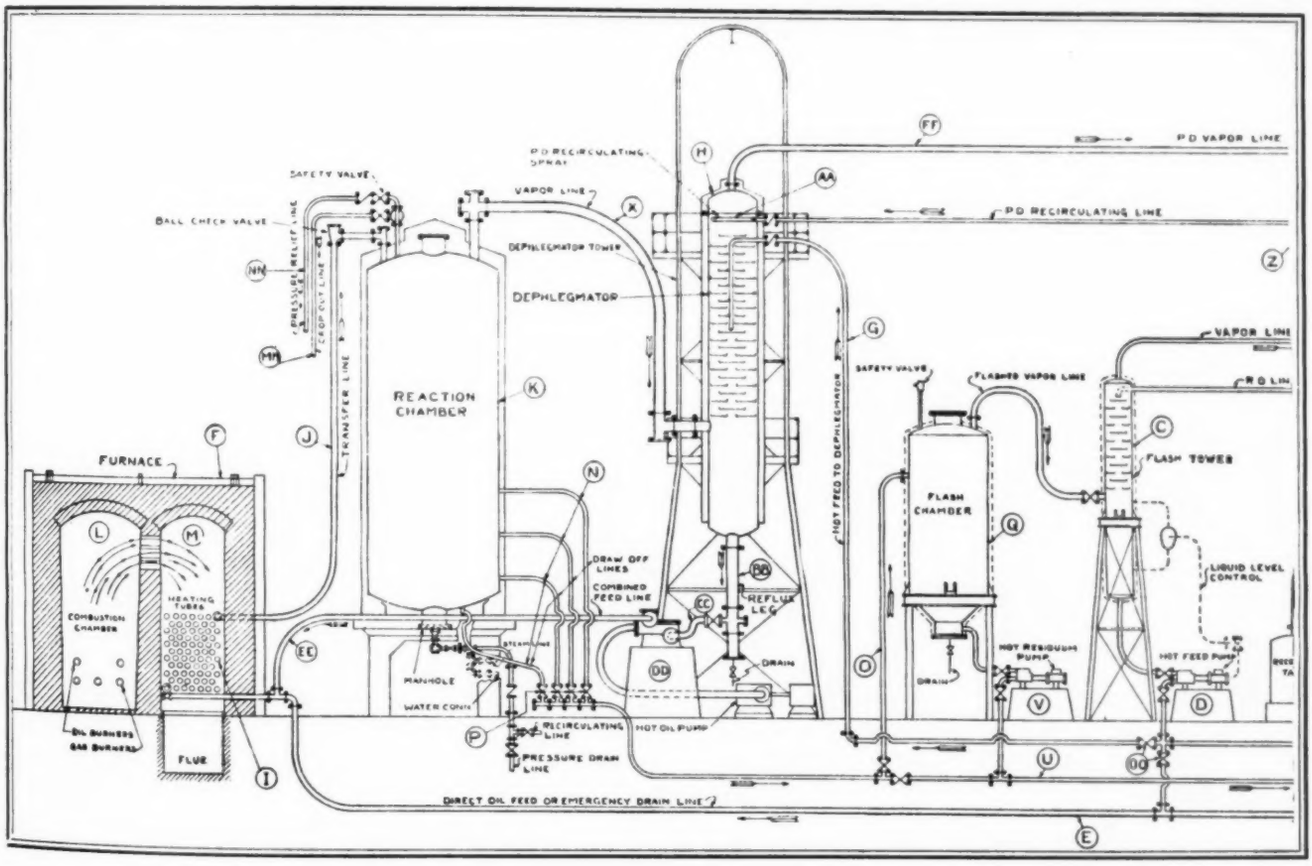
culable detriment to nerve force and to health. A clear correlation has been recorded between smoky periods and the diseases of bronchitis and pneumonia. All this harm due to smoke would be eliminated were gas exclusively used as fuel, due to its smokeless and ashless combustion. Every step leading to the increased use of gas is a measure for industrial efficiency, cleanliness and public health. The cracking process can produce almost incalculable amounts of gas whenever the economic demand is present, due to the almost inexhaustible volumes of crude petroleum.

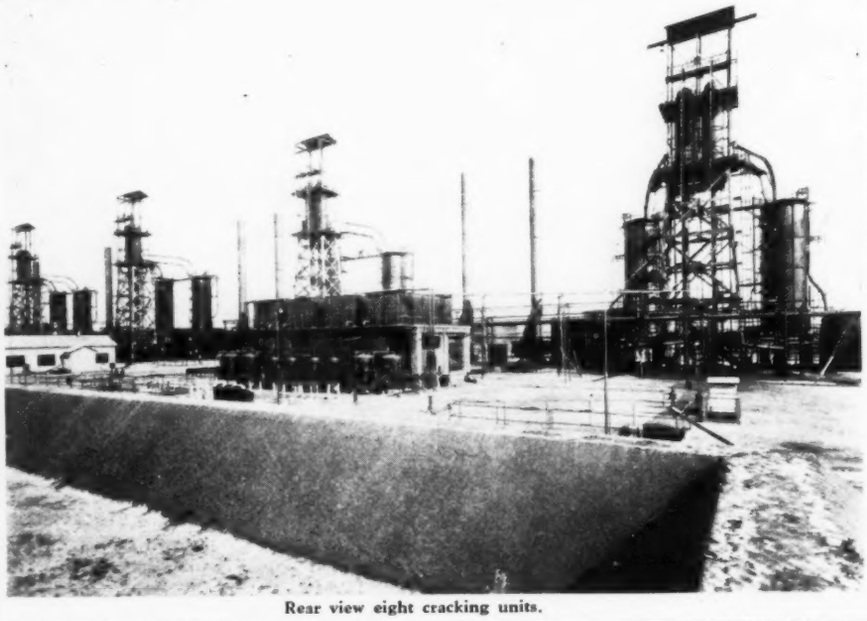
Front view eight cracking units.

The cracking process has been considered chiefly as a means of producing gasoline from petroleum. But it is more than that. It can convert petroleum oils, coal tars, shale oils, even vegetable and fish oils, into motor fuels and other products as well. With the increasing employment of all products, especially gas, the cracking process must be considered not solely an agency for the production of gasoline. The cracking process is so flexible that it can be operated for that balance of products which will bring greatest market return. This may mean gasoline, gas and coke; or less gasoline and furnace oil, fuel oil, coke and gas; or it may mean operation for maximum yields of gas. With no change in equipment, and but slight modification in operating conditions, demand for any product can be met.

The petroleum industry has been troubled by two accusations; first, that it is exploiting a resource which will not last and which is certain to be exhausted in the near future; and, second, that in the utilization of this resource it is operating in a manner inconsistent with conservation. In regard to petroleum resources, it may be asserted with confidence that the total amount of crude oil in the earth's crust is immensely greater than any estimate yet published.

Geologists state that oil discovery is a possibility in 1,100,000,000 acres in the United States alone, or fifty-six per cent of its total land area. The contrast of this huge territory with the 2,000,000 acres producing oil at the present time, makes it certain that new fields will be continually discovered and that the oil of that country will prove ample





Rear view eight cracking units.

for many years to come. What is true regarding the potential oil production of the United States probably is true in even greater measure for many of the other countries of the world, where oil exploration has been even less thorough than in the United States.

From the beginning of production on a significant scale in the year 1857 to the end of 1929, the oil fields of the world produced 18,500,000,000 barrels of petroleum. But this is only a fraction of the oil resources of the producing areas. It is estimated that at most twenty per cent of the oil in the ground is brought to the surface by present methods of recovery. For every barrel of oil produced at least four barrels remain in the earth. While 18,500,000,000 barrels of oil have been produced, 74,000,000,000 barrels or more are still in the oil sands. This oil alone, could it be recovered by means of flooding, repressuring or mining, would supply the world's needs for over fifty years at present rate of consumption.

Since the foundation of the petroleum industry, many predictions of oil shortage have been made. In 1922 it was stated quite positively that the oil reserves in the U. S. were not over seven billion barrels of crude oil. Since that statement was made, more than seven billion barrels of crude oil have been produced, and the known supply at present is the greatest ever known. The present difficulty in the oil industry is not scarcity of oil but rather an immense overproduction.

Proration and drilling agreements are holding back a veritable flood of crude, which could be produced in amounts far exceeding present requirements. In view of the known crude oil reserves, the vast amount left underground by present production methods, and the undiscovered fields that no doubt exist, an oil shortage is far in the future.

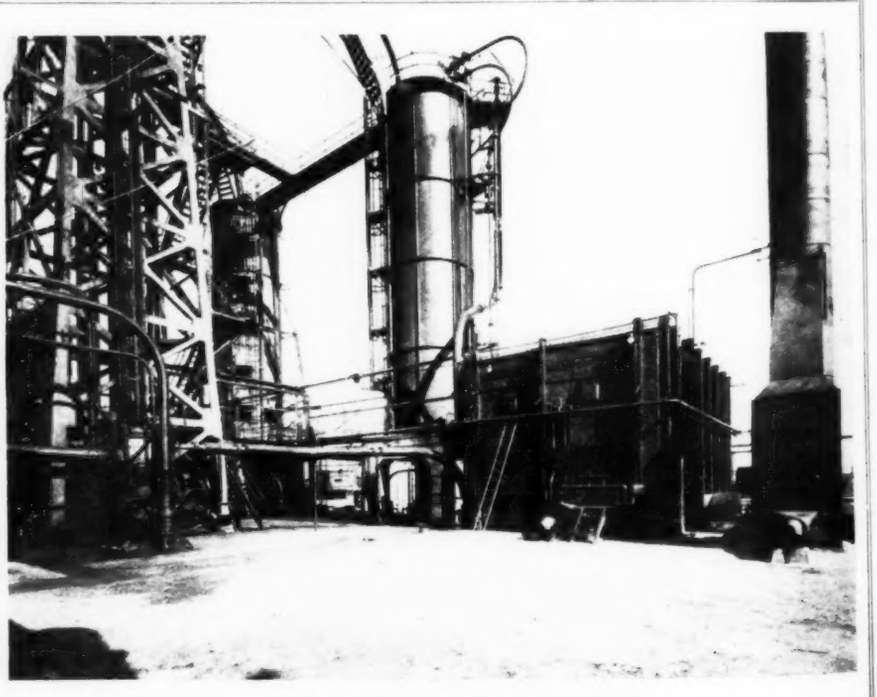
It is important to the gas industry that it be insured an adequate supply of oil for gas making.

It may not be too optimistic to predict, considering past and present experience throughout the world, that petroleum oil will be our dominant source of gasoline, and for gas also, for at least a century to come.

Conservation of Crude Oil Due to Cracking.

No doubt in some respects the utmost attention to conservation has not been shown in the production and utilization of petroleum. Lack of unit control in producing fields, waste of gas, and excessive production forcing oil into use that should properly belong to coke or coal, are not consistent with the wisest use of our crude oil resources. However, the oil industry is making every effort to conserve their crude oil supply and applying scientific methods, not alone to crude oil production, but also in its refining. Crude oil conservation is due in a large measure to the cracking process.

Due to the fact that one-third of our gasoline is made by cracking instead of by the simple distillation of crude oil, it is necessary to produce far less petroleum than would be required were the cracking process not in use. During the year 1929, conservation of 540,000,000 barrels of crude oil was brought about by the cracking process which produced 6,035,400,000 gallons of gasoline from oils which contained no gasoline as such. If it had not been for the agency of the cracking process, the oil fields of the world would have been called upon for 2,000,000,000 barrels of oil during the year 1929 instead of the 1,478,000,000 actually produced, which was sufficient (in fact more than sufficient) to supply the requirements of the world's 33,000,000 automotive ve-



Close-up view, cracking unit and reaction chamber.

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TIW-63

hicles. During the last fifteen years the saving in crude oil due to the cracking process is conservatively estimated at over 1,900,000,000 barrels.

Had all of the gasoline of recent years been produced by simple distillation of crude oil, vast quantities of fuel oil would have been thrown on the market, probably depressing it considerably and bringing the oil into greater competition with coal. It is far more fitting, as a national policy, to utilize fuel oil for gasoline and other products such as gas, which may be termed the higher uses, rather than burning it under boilers.

The Development and Magnitude of the Cracking Process.

The commercial cracking of heavy oils into gasoline is of comparatively recent development. Nevertheless it is the life and sinew of the oil and automobile industries. There are few refiners of crude oil who could operate economically without the cracking process as part of their regular equipment. The automobile industry could scarcely have developed to its present size were it not for the supply of gasoline made available by cracking. Without this process, the price of motor fuel would be distinctly higher than it now is.

Vast amounts of money have been expended in working out the commercial conversion of fuel oils into gasoline and other products by cracking. It is estimated that over $45,000,000 has been spent in endeavors to develop commercial processes.

The improvement which has been made in cracking units in their evolution during the last two decades or so has been startling. The early shell cracking stills, some of which are still in use, had a daily capacity of approximately 125 barrels each. They were limited to the use of a selected gas oil charging stock, and their yield of gasoline was about thirty per cent. The modern cracking process employs units having a daily capacity of 750 to over 3,000 barrels per day, converting crude, or heavy oil, into gasoline with yields of fifty to over seventy-five per cent. Despite the somewhat greater complexity of the modern pressure still, its high efficiency makes the first cost, per barrel of gasoline produced per day, but one-fourth of that of the early cracking units. Had it not been for the great advance in the process of cracking, the investment necessary to produce the present volume of cracked gasoline would be over $1,200,000,000, instead of $330,000,000, the approximate value of the world's present cracking equipment and its auxiliaries, such as storage tanks, agitators, rerun stills, boiler houses, land, etc.

The use of the cracking process is world wide. Commercial plants are now in operation or under construction in such widely separated countries as Japan, Borneo, Great Britain, Java, Russia, the Dutch West Indies, Australia, Roumania, India, Belgium, Italy, Argentina, Trinidad, and Canada, as well as in all the refining areas of the United States.

During 1929 in the United States one hundred and eighty-six of the three hundred sixty-two operating refineries were equipped with cracking units. These are the largest and most modern of the refineries. The total cracking capacity is 1,705,299 barrels of charging stock per day. In 1929 the United States refineries produced 143,700,000 barrels, or 6,035,400,000 gallons of cracked gasoline, which was about 33 per cent of the total motor fuel produced.

The Residual Oil Type of Cracking Operation.

The cracking process may be operated for maximum yields of gasoline, furnace or Diesel oil, residual oil having higher B. T. U. content per barrel than the original charging stock, coke, or gas. Or viscous oils may be used as charging stock and cracked but lightly in order to lower their viscosity and cold test so that they will flow readily through pipe lines. The manner in which the process is used will depend upon market conditions and the oil available for cracking.

Residual oil type operation permits the production of high yields of gasoline, furnace or Diesel oil and a minimum amount of coke and gas, while the residual fuel oil has a higher thermal value per barrel than the original charging stock. Or gas may be produced in maximum volume by changing the operating conditions.

The operation of the cracking process will best be understood by a description following the flow chart of a typical installation. Photographs of commercial cracking plants are also shown.

Residual oil type operation will be considered as carried out in a unit equipped with the flashing system, in which the volatile portions of the residuum are taken off by "flashing" the residual oil into a chamber at lower pressure. In non-residuum operation the flash chamber is not employed and the coke is deposited in the reaction chamber.

The oil to be cracked is pumped to the plant at a uniform rate by pump A, the suction side of which is connected to the oil storage tank. The raw charging stock may be pumped into the flash condenser C, to the dephlegmator H, or directly to the heating tubes I. All the charging stock may be pumped to any one of these elements of the cracking system, or it may be split as the operating conditions warrant. The charging stock pumped into the flash condenser C comes into intimate contact with the vapors from the flash chamber Q, so that the temperature of the charging oil is raised by condensing a portion of the vapors. The charging stock and condensed vapors are drawn from the bottom of the flash condenser C by the hot oil pump D and discharged into the dephlegmator H by means of the pipe connection G. The preheated charging stock comes into contact with the hot vapors in the dephlegmator and thereby is raised to a substantially higher temperature. As an alternative, part or all of the charging stock and condensed vapors from the flash condenser may go directly through the feed line E to the heating tubes I. The valves OO control the proportion of the split feed which passes to the heating coil I or to the dephlegmator H. The feed oil enters the heating coil at a temperature of approximately 725 degrees F., and passes through the heating tubes, which are connected by return bend fittings to form a continuous coil. The oil is heated by the gases generated in the combustion chamber L, attaining a cracking temperature of 900 degrees F., more or less. The products of combustion pass through port holes in the upper part of a wall which divides the furnace into two chambers, and comes in contact with the heating coil in chamber M. The combustion gases flow counter to the direction of the oil in the heating tubes, and the spent gases pass through a flue to the stack. The heated oil leaves the last tube of the coil and discharges from the transfer line J into the reaction chamber K. The reaction chamber is not fired or heated externally and is thoroughly insulated against heat losses.

The residual oil is withdrawn from the lower portion of the reaction chamber K through the draw-off pipe connections N by means of control valves P. The residual oil then passes through line O into the flash chamber Q, which is maintained under a pressure lower than that of the reaction chamber K. Here the lighter portions of the residual oil are flashed off as vapors, leaving a heavy residuum to be drawn off from the bottom of the flash chamber. The vapors pass from the chamber Q to the flash condenser C, where they are brought into contact with fresh charging stock to which they give up a portion of their heat, and where they in part undergo condensation. The uncondensed vapors pass through the line R to the cooling coil S and are collected in the receiver T. The hot residual oil from chamber

Q may pass through the cooling coil W to a storage tank, or it may be burned in the combustion chamber L while still in a heated condition.

The cracked vapors leave the top of the reaction chamber K through the vapor line X, which is connected to the dephlegmator H, where they mingle with the ingoing preheated cracking stock.

The temperature of the vapors leaving the dephlegmator H is maintained at any point desired by cooling with pressure distillate oil. This cooling is accomplished by means of a pump Y which discharges a portion of the pressure distillate drawn from the receiver HH into the recirculating line Z, the oil then entering the dephlegmator through the spray pipe AA.

The reflux condensate oil from the dephlegmator H, mixed with fresh charging stock, passes through the reflux leg BB, and by means of the hot oil pump DD is discharged through pipe connection EE into the coil of heating tubes in the furnace, wherein it is subjected to cracking conditions.

The dephlegmator H is of the perforated pan type, which gives efficient contact of oil and vapor. The use of charging stock and pressure distillate oil as cooling means secures a refluxing action in the dephlegmator so that the light hydrocarbon vapors leaving the top of the dephlegmator through line FF may be of any quality desired. This light hydrocarbon vapor is condensed to a liquid as pressure distillate or crude gasoline in the cooling coil GG, from which it passes into receiver HH, maintained under the operating pressure of the system. The pressure distillate discharges through the meter SS, into a gas separating chamber JJ, from which it flows to a storage tank, through the trap LL. The operating pressure on the system is controlled by the gas valve RR through which gas in excess of that necessary to maintain the pressure desired leaves the receiver HH, mixing with the gas evolved from the pressure distillate due to the reduction of pressure in the separating tank JJ. The gas mixture flows through the line KK and connected pipes to the gasoline absorption system or to the burners in furnace F., or it may be passed to storage to be converted into chemicals or shipped to gas companies to be blended with gas of low B. T. U. value, such as water gas. If desired, the gas from the receiver HH may be taken off separately from the gas evolved from the pressure distillate in receiver JJ.

The following data in Table 1, covers the results obtained from the cracking of gas oil, topped crude, and fuel oils, from the Mid-Continent Field, West Texas and California in the United States in commercial units. The amounts of charging stock given in the table were cracked in each case in a single continuous operation without shut-down of the apparatus.

Simultaneous Cracking and Coking of Heavy Oils (Non-Residuum Operation).

In another form of operation the cracking process produces only pressure distillate oil (or crude gasoline), gas and coke. This mode of operation treats kerosene distillate, gas oil, topped crude, crude itself or any other oil available and eliminates the use of coking stills which are necessary to prepare charging stock for cracking units limited to special distillate oil. Since the coking of heavy oils in shell stills is a costly operation, the simultaneous coking and cracking of heavy oil is a means of effecting great savings. Performing the cracking and coking in a single step requires no installation beyond that used in residual oil operation, the only changes being slight variations in the operating conditions.

In Table 2 following are presented data from the simultaneous cracking and coking of different oils in commercial practice:

Table 1—Residuum Type of Operation

Charging Stock	California Gas Oil	Signal Hill & Los Angeles Basin Fuel Oil	West Texas Residuum	Mid-Cont. Gas Oil	Wax Dist.	Mid-Cont. Fuel Oil	Mid-Cont. Wax Oil
Gravity, degrees A. P. I.	26.5	18.4	21.1	32.8	28.9	24.0	19.9
Operating pressure, pounds	300	170	184	275	169	200	180
Transfer temperature, degrees F.	887	940	888	889	890	887	895
Number hours operating	866	89	233	251	756	138	124
Total through-put, barrels	81,592	7,000	31,922	30,554	48,510	10,352	5,826
Pressure distillate oil, yield, per cent	59.5	36.6	45.9	71.4	62.2	58.5	61.8
Gravity, degrees A. P. I.	53.0	56.6	58.4	57.1	52.0	57.5	51.7
Residuum oil, yield, per cent	33.0	54.6	48.5	21.8	30.6	34.0	30.7
Gravity, A. P. I.	8.1	8.6	8.0	7.5	10.7	.....	.....
Coke, pounds per barrel oil charged	0.1	.....	0.025	6.9	.....	13	15.4
Gas, cu. ft. per barrel oil charged	390	401	437	500	480	540	460
Gasoline yield, per cent of raw oil	56.6	35.9	45.0	58.4	44.7	52.7	51.6
Diesel or furnace oil, yield, per cent	1.0	.....	.....	8.7	16.0	3.9	8.3

Table 2—Non-Residuum Operation

Charging Stock—	Mid.-Cont. Fuel Oil	W. Texas Fuel Oil	Seminole Fuel Oil	Slick & Boggs Topped Crude	W. Texas Fuel Oil	Mid.-Cont. Fuel Oil	Mid-Cont. Topped Crude	Wax Dist.	Los Angeles Basin Topped Crude	Penna. Gas Oil	Penna. Gas Oil
Gravity, degrees A. P. I.	23.9	20.9	24.8	24.2	21.5	24.3	25.5	30.0	18.3	39.3	38.4
Operating pressure, pounds	200	187	.....	188	185	190	185	250	140	220	285
Transfer temperature, degrees F.	922	927	910	913	882	895	910	925	940	915	925
Number hours operating	36	36	39	43	43	28	71	63	32	.....	104
Total throughput barrels	2,643	3,830	3,137	2,638	4,951	2,665	4,835	4,476	1,589	75,568 (Total for mo.)	5,583
Products Derived from Cracking.											
Pressure distillate, yield, per cent	78.6	80.7	84.7	80.9	82.71	80.9	81.5	73.9	72.9	86.0	82.2
Gravity, degrees A. P. I.	53.1	50.4	55.6	53.6	51.0	54.0	52.7	55.8	47.5	57.5	54.5
Coke, pounds per barrel oil charged	63 0	76.7	66.4	.....	59.7	37.5	58.5	67.5	94.4	34	27.1
Gas, cu. ft. per barrel oil charged	750	810	.....	635	600	400	430	575	.....	425	530
Gasoline yield, per cent of charge	64.3	64.5	66.0	61.3	67.66	60.3	60.8	63.8	54.5	70.3	68.0
Diesel or furnace oil yield, per cent	12.0	14.1	16.0	17.0	12.0	16.2	.....	7.0	14.4	13.9	12.5

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The Improved American Oil and Gas Separator was designed with dry gas as its objective. Bone-dry gas is positively assured. The extra oil you save will soon pay for the Improved American.

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AMERICAN
OIL FIELD EQUIPMENT
Always Dependable.

B.S.& B. Products

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Much equipment in the oil fields is built on conjecture. Quite the contrary, the Improved American Oil and Gas Separator has been thoroughly ENGINEERED. Experimental Separators were first constructed with glass windows so as to observe each step in the process of oil and gas separation. Every improvement has been designed for a definite purpose. Each improvement has been carefully studied and tested before being incorporated in the Improved American.

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The Improved American has met every test imposed upon it under the severe conditions in the Oklahoma City field—on oil wells and gas wells alike. This separator is producing results that exceeded expectations. The demand for the Improved American in this field of large oil volume and high gas pressure is ample proof of its high efficiency.

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The Improved American is equipped with an inside float. An inside float can be much larger than an outside float, which results in greater buoyancy and which in turn produces more power to operate the oil valve. It is ten times as effective as the obsolete outside float. "A man to do a man's work".

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The Improved American is equipped with a Tangential Inlet. Unlike the ordinary inlet with its internal deflector the tangential inlet does not retard the force of the incoming oil and gas flow. It is so designed that centrifugal force is utilized to the utmost degree.

This inlet is built entirely inside the separator. Notice the absence of projecting fittings. There is no threaded connection to become damaged through rough handling.

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The utilization of coal in the future will probably be in large measure through low temperature carbonization. This process has the advantage of producing a smokeless solid fuel, gas and relatively large amounts of tar. The tar can be commercially converted into motor fuel by the cracking process.

While the yields are not always large, the motor fuel from coal tar is of very high anti-knock value and is valuable not only as premium fuel suitable for high compression motors, but as blending stock to bring up the knock rating of poorer gasolines.

F. Anti-Knock Properties of Cracked Gasoline

One of the most important problems of the oil industry today is the production of anti-knock motor fuels. Gasolines produced from crude oils of the major fields of the United States by simple distillation develop the familiar knocking sound when used in high-compression automotive engines or in ordinary engines when laboring on hills with wide open throttle.

The knocking propensity of gasoline is primarily a function of its chemical composition. The work of Ricardo, Midgeley, Boyd and others has shown that in their anti-knock properties the hydrocarbons of the various series stand in general in the following order:

1. The paraffin hydrocarbons are the worst knockers.
2. The unsaturated hydrocarbons knock materially less than the paraffins.
3. The naphthene hydrocarbons are distinctly better as anti-knock material than either the unsaturated or the paraffin hydrocarbons.
4. The aromatic hydrocarbons are non-detonating under any practicable motor compression ratio.

These are, however, only approximate rules, as in each group there are great differences between individual members. The best burning paraffins, for example, knock less than some of the olefines, while some olefines have been found to have three times the effect in checking detonation than benzene has.

For many years it was held that straight-run gasolines from paraffin base or semi-asphaltic base oils were the superior motor fuels. However, cracked gasolines have been in demand, and at present they are often sold at premium prices. In anti-knock properties they are better than the straight-run product. This is due to their higher content of olefine, naphthene and aromatic hydrocarbons.

Cracked gasolines vary in composition among themselves, differing both by reason of the nature of the charging stock and the conditions of the cracking operation. Oils from California and certain Texas fields give gasoline of particularly high anti-knock rating, but by proper control of cracking even Pennsylvania crudes, which are notorious for the knocking of the gasoline produced from them, can be converted into gasoline of high anti-knock value.

As a preliminary to a study of the cracking of such oils, twelve samples of premium anti-knock gasoline, containing a chemical anti-knock agent, were purchased from filling stations. The knock rating of these samples expressed by the proportion of benzol in admixture with Pennsylvania straight-run gasoline necessary to give anti-knock properties, ranged from 45 to 53 per cent. By cracking Pennsylvania gas oil in commercial units gasoline was manufactured with a knock rating, measuring in different runs, from 47 to 53 per cent. The cracked gasoline from this badly knocking crude was thus an excellent non-detonating fuel, equal to that being marketed commercially at a premium. In the table below are given the anti-knock ratings of a number of cracked gasolines:

Charging Stock	Cracked Gasoline Benzol Value Per Cent
Pennsylvania Gas Oil	47-53
California	55
Utah Low Temperature Coal Tar	65

In a second table are given comparative analyses of straight-run and cracked gasoline from a number of sources. The effect of the cracking process in converting paraffin hydrocarbons into those of less knocking groups is evident.

United States	Unsaturated Hydro-Carbons	Aromatic Hydro-Carbons	Naphthene Hydro-Carbons	Paraffin Hydro-Carbons
Pennsylvania Straight run	2.5	Trace	14.9	82.6
Pennsylvania cracked	16.8	23.1	12.1	48.0
Mid-Continent Straight run	2.9	3.9	19.7	73.6
Mid-Continent cracked	15.0	18.5	12.6	53.0
California Straight run	2.2	10.4	28.1	58.0
California cracked	25.8	10.8	19.8	43.6
Smackover cracked	16.8	23.1	12.1	48.0
Cushing, Okla., Straight run	1.6	4.9	23.7	69.8
Cushing, Okla., cracked	10.9	19.8	18.0	51.3
Somerset, Ky., Straight run	3.8	5.3	20.6	70.3
Somerset, Ky., cracked	12.5	14.9	11.8	60.8
Straight run gasoline from Roumanian crudes as follows:				
Bustenari	3	13.3	29.0	54.7
Arbanasi	4	24.0	14.0	58.0
Ceptura	2	7.2	20.1	70.7
Arbanasi	....	15.7	21 to 23	61.3 to 63.3
Moreni	....	23.3	16.2	60.5
Roumanian cracked gasoline after chemical treatment	9.7	28.9	17.4	44.0
Before treatment	19.0	23.5	14.6	42.9

G. The Chemical Treatment of Cracked Gasoline

All cracked gasolines can be commercially treated with sulphuric acid, caustic soda, sodium plumbite and water followed by fire and steam distillation. Recently Halloran has found that by carrying out the acid treatment of cracked distillates at low temperatures the losses may be greatly reduced. Below —9 degrees C. (15 degrees F.) sulphuric acid appears to have preferential solubility for sulphur compounds, while the vigorous polymerizing effect and other chemical actions manifested at higher temperatures are markedly reduced. As a function of the type of motor fuel to be refined the amounts of chemicals used and the order of adding them are varied as required to cause the gasoline to pass market standards. The treating of cracked gasoline to meet drastic specifications adds to its cost in a threefold manner in that chemicals are consumed, the gasoline is depreciated in quality by the loss of anti-knock constituents, and there is actual loss of gasoline through reaction and solution in the acid, and polymerization of some of the hydrocarbons into high boiling compounds. It is therefore desirable that cracked gasoline be given a minimum of treatment in order to save chemicals, to conserve gasoline, and to retain its anti-knock properties.

Valuable Information Gained from

Year's Study *of* Pipe Line Corrosion

By STANLEY GILL,
Research Department, Gulf Oil Corp.

Introduction

Of the numerous, more or less severe, corrosion problems with which the petroleum industry must deal, none is more important than that presented by the soil corrosion of buried pipe lines. In other branches of the industry there exist corrosion problems which are very severe, but these are confined for the greater part to isolated areas or pieces of equipment; soil corrosion, on the other hand, exists in greater or lesser degree wherever pipe lines are buried in the soil. Since oil pipe lines represent more than one-half of the total mileage of buried pipe in the United States, soil corrosion is necessarily a subject of major interest to the petroleum industry.

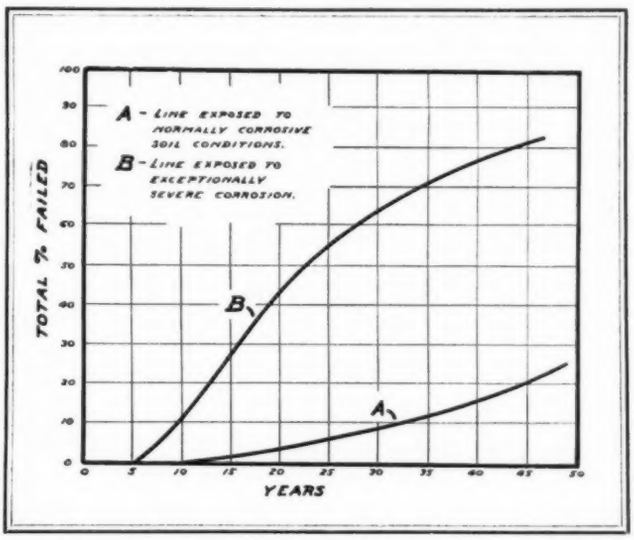


Fig. 3—Curves illustrating distribution of corrosion over typical pipe lines.

The study of soil corrosion of pipe lines comprises many phases, ranging from those which are concerned with methods to be employed in operation and preservation of pipe lines and which deal, in a broad sense, with the engineering phases of the subject, to purely theoretical studies of the fundamental nature of soil corrosion. Connecting these extremes are the steps whereby results of theoretical research are translated and interpreted in the light of their economic value, and ultimately given a place in engineering practice.[2] The condensed discussion which follows covers a few of the more important of these many phases of present studies of the corrosion of oil pipe lines; it is not intended to be at all thorough, but merely to present a general survey of our present knowledge of the problem, and of the steps which are being taken to increase that knowledge.

Studies of Corrosion Experience

Perhaps the most useful tool available in developing methods for combating soil corrosion is the study of the corrosion which takes place in the operation of existing pipe lines. The great value of data thus accumulated lies in the fact that they represent actual operating conditions; that they alone make possible a true evaluation of the losses occasioned by corrosion of buried pipe lines, and that speculative or accidental factors may be largely eliminated from studies of this character.

The necessity for keeping accurate records of the corrosion experienced on a pipe line system would seem to be obvious; unfortunately, many pipe line operators have failed to recognize this necessity. Such accurate records serve two very important ends. First, by showing the operator the exact condition of his lines, they enable him to maintain old lines and protect new lines with a full knowledge of the need for maintenance or protection, and with an idea as to the return to be expected from his investment in maintenance or protection. Second, they provide invaluable data applicable to fundamental studies of the nature of soil corrosion—of its distribution and severity, of the economic losses it entails, and of its relationship to soil composition, topography, climatic conditions, etc.

Much valuable information has been disclosed through studies of the corrosion which has taken place on various pipe line systems.

In the course of time, as data are accumulated, more precise conclusions will be possible; it may also be possible to develop workable generalizations whereby the probable depreciation of a pipe line can be predicted. As regards this latter point, no truly accurate statement can be made at the present time, excepting the statement that the average corrosion rate experienced by buried pipe is lower than it has been thought to be.

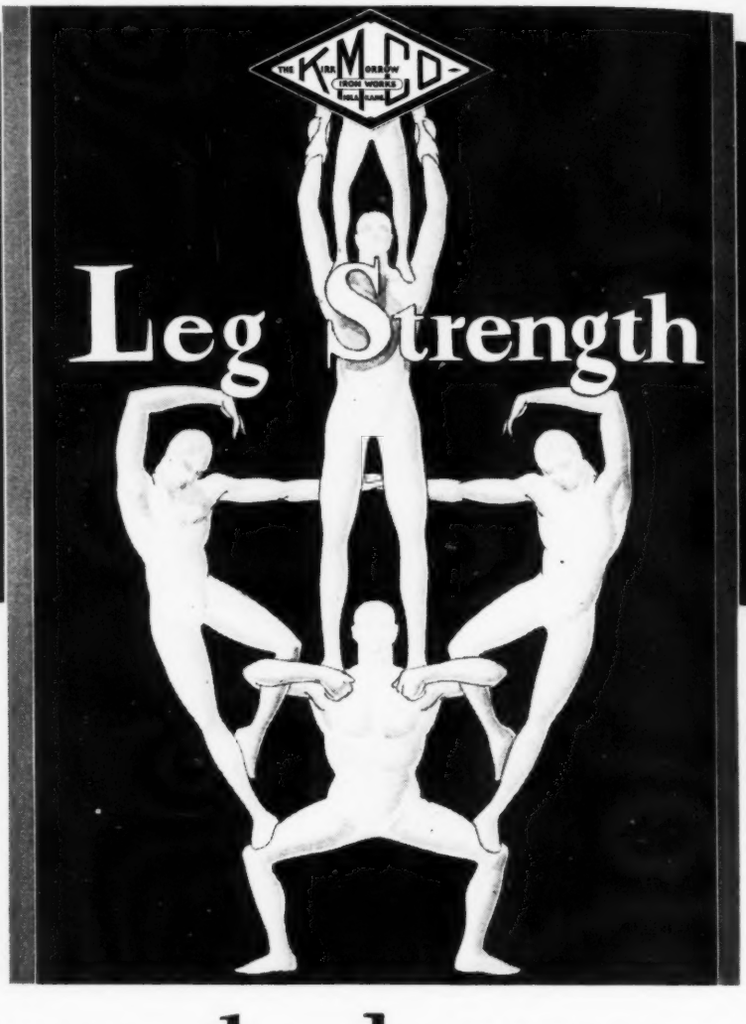
Figure 3 illustrates the type of distribution of corrosion which is experienced over pipe lines: *A* is based upon data from a large number of lines and is a fair approximation of average corrosive conditions; *B* is based upon a few lines which traverse soils of an extremely corrosive character.

Protection of Pipe Lines

Increased knowledge of the nature and distribution of corrosion on buried pipe lines may be expected to exert great influence upon the methods to be employed in protecting them against corrosion. The reasons which dictate the use of protective measures are purely economic; the prevention of soil corrosion is necessary only because corrosion increases costs of operation. Hence, information as to the extent, seriousness and cost of pipe line corrosion results in a more intelligent and economical use of methods of protection.

Much progress has been made, and is being made, in the development of coatings for the protection of buried pipe lines. Many really effective coating systems are available,

[2] Engineering practice must, in many industries, be more or less ahead of theoretical development. This implies no disparagement of the value of theoretical work, upon which engineering advancement must necessarily be based. It is true, however, that many industrial problems are so urgent, and at the same time so obscure from a scientific standpoint, that the engineer is faced with the necessity of improvising a solution without awaiting the results of scientific study. Such improvised methods will be revised and improved in the light of later and fuller knowledge of the scientific elements of the problem, but the pressure of economic necessity forces the engineer to move more rapidly than his scientific colleague.



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Pipe lines laid in swampy country.

and numerous improvements and developments are to be expected. It is significant that more and more use is being made of more or less expensive coating systems; that the present tendency is to use coatings of proven effectiveness rather than to coat lines with materials whose most important qualifications are that they are "black and cheap."

Numerous discussions of the status of the art of pipe line protection have been published during recent months.[4]

Table I contains estimates as to the probable increase of pipe life to be expected from the use of coatings of various types and should be considered only in connection with the paper with which it was originally published.[5]

TABLE I

Type of Coating	Years Life of Bare Pipe: Less than 5 years	5-10 years	10-20 years
Cut-back bitumens	0	0-1	1- 5
Greases, not reinforced[1]	0[1]	0[1]	0- 1[1]
Emulsions	0	0	0- 1
Soft bitumens applied molten:			
Not reinforced	0	0-1	1- 5
1-ply wrapping[2]	1-2[2]	1-4[2]	2- 5[2]
2-ply wrapping[2]	2-4[2]	2-5[2]	3- 7[2]
3-ply wrapping[2]	2-5[2]	3-7[2]	6-10[2]
Pipe-line enamels:			
Not reinforced	½-1	1-3	3- 6
Reinforced	3-5	4-8	7-12

[1] Much better results than those indicated will be obtained from the greases under certain soil conditions.
[2] These figures assume average good practice in application of the coatings.

Note: This table is taken from a paper by the writer which was published in the Oil Weekly, March 14, 1930, and should be used only in connection with that paper.

[4] Gordon N. Scott: "Field Inspection of Protective Coatings Applied to Oil and Gas Lines," proceedings tenth annual meeting of the American Petroleum Institute, 1929, Part IV.
Gordon N. Scott: "The Use and Behavior of Protective Coatings on Underground Pipes," American Petroleum Institute Bulletin 10, No. 2, p. 78 (1929).
Charles Fitzgerald: loc. cit.
Stanley Gill: "Protection of Buried Pipe Lines Against Corrosion," Oil Weekly, March 14, 1930.
[5] Stanley Gill: loc. cit.

Prelocation of Corrosive Spots

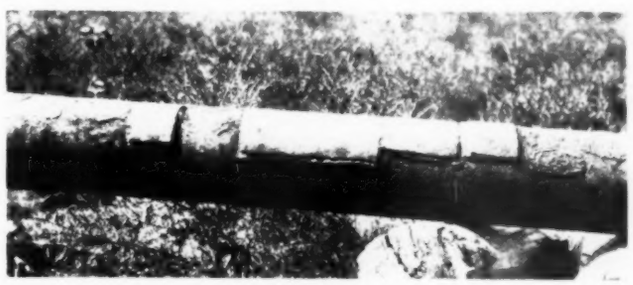
It is obvious that the most effective use of protective methods could be made if it were possible to determine before a line was laid just what portions of the pipe would be exposed to the most severe corrosive action. If this information were available, it would be possible to proportion expenditures for corrosion prevention to the severity of the corrosive conditions on various portions of the line. Unfortunately, there is available no practical and accurate method for such predetermination of soil corrosiveness. Much work is being done toward the development of such methods, but it is extremely improbable that this will result in any practical procedure. Where new lines are laid parallel to existing pipe, the corrosion experienced on the old line will serve as a guide to the expected corrosion of the new line. Where such experience is not available, a simple survey of the proposed right-of-way by engineers experienced in soil corrosion of pipe lines is the most reliable and least expensive method of estimating probable corrosion. Chemical methods, because of the doubtfulness of correlation between chemical determinations and corrosion, which will be discussed below, are without particular value for the purpose; even if the results of chemical tests were more valuable, they would be so slow and expensive as to be impractical.

Use of Corrosion-Resistant Metals

Factors similar to those which must influence expenditure for coatings must also be considered in connection with the use of corrosion-resistant metals or alloys in pipe line construction. This means that there will be relatively few cases in which large expenditures for expensive corrosion-resistant alloys will be justified.

Among the metals which are available there are few which have as yet demonstrated conclusively a consistently superior resistance to soil corrosion. This will be evident from a careful analysis of the excellent data which have been obtained by Mr. K. H. Logan in a series of tests of the corrosion resistance of various common pipe materials.[6]

[6] K. H. Logan: "Soil Corrosion Studies, 1927-1928," U. S. Bureau of Standards Journal of Research, 3, 275 (1929).



Patch welding corroded pipe.

Line pipe uncoated, showing effects of corrosion.

Line pipe, showing effects of corrosion.

In certain soils some of these materials may possess an advantage which will warrant their use. For example, there is some evidence to support a belief that certain materials have a superiority over others under soil conditions in which corrosion is accompanied by the formation of a scale of insoluble corrosion products. This conclusion is by no means thoroughly established, but is believed to be sound to a degree.

There is also reason to believe that worthwhile results can be obtained under some specially severe soil corrosion conditions through the use of various coatings.

Effect of Oil-Soaked Soil

An important factor in the soil corrosion of oil lines is the acceleration of soil corrosion which is produced by the presence of oil in the soil. It has been found to be almost uniformly true that when a soil becomes oil-soaked from leaks or breaks in a line, its corrosiveness is greatly increased. There are three probable causes for this. These are:

A. The oil-soaked soil retains moisture to a much greater degree than does soil which is free from oil.

B. The oil excludes oxygen from that portion of the pipe surface with which it is in contact, thus establishing oxygen concentration cell effects.

C. It has been shown that petroleum hydrocarbons are decomposed by bacteria with the formation of acidic products. This is probably the most important of the three causes listed.

The effect of oil-soaked soil is very widespread and is probably responsible for at least 25 per cent of the soil corrosion which is experienced on oil lines.

Electric Currents on Pipe Lines

Attention has recently been drawn to the fact that buried pipe lines carry considerable quantity of electric current aside from that which may be classified as stray currents.[7]

The investigation of these phenomena has not yet proceeded to a point where definite conclusions can be drawn. They are, however, of considerable interest and may possess some importance in relation to corrosion.

Effects of Soil Composition

As a part of both the scientific investigation of the nature of soil corrosion and of attempts to predetermine the corrosive character of soils, much effort is being expended upon the establishment of correlations between corrosion and the nature of soils.[8] Up to the present time this work has not resulted in any definite or consistent correlation between corrosion and any single factor of soil composition. The reason for this is fairly obvious when it is considered that there exist a very large number of factors, any one of which may control the course of pipe line corrosion in a given cast. It has been found that there are a number of factors of soil composition which correlate to a certain extent with corrosion experienced. Among these may be listed the hydrogen ion concentration of the soils, the total acidity of the soils, the electrical conductivity of the soils, which is related to the content of soluble salts, and the colloidal nature of the soils. Topographical features which influence the accumulation of moisture in contact with the pipe also exert a great influence, as do climatic conditions, particularly those relating to rainfall. All of these factors correlate to a certain extent with actual corrosion experience, but no one of them can be tied down to corrosion in all cases. Roughly, it may be said that any one of the factors listed may be expected to correlate with corrosion experience from 60 to 70 per cent. Such a correlation is not, of course, consistent enough to be of great value, but studies of this type may be expected to result in valuable contributions to our knowledge of soil corrosion.

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[7] Logan, Rogers & Putnam: "Pipe Line Currents," proceedings tenth annual meeting A. P. I., Part IV, page 116.
Gill: "Electric Currents in Pipe Lines and Their Relation to Corrosion."

[8] Logan: "Soil Corrosion Studies, 1927-1928," U. S. Bureau of Standards Journal of Research, 3, 275 (1929).
Holler: "Corrosiveness of Soils With Respect to Iron and Steel," Industrial and Engineering Chemistry, 21, 750 (1929).

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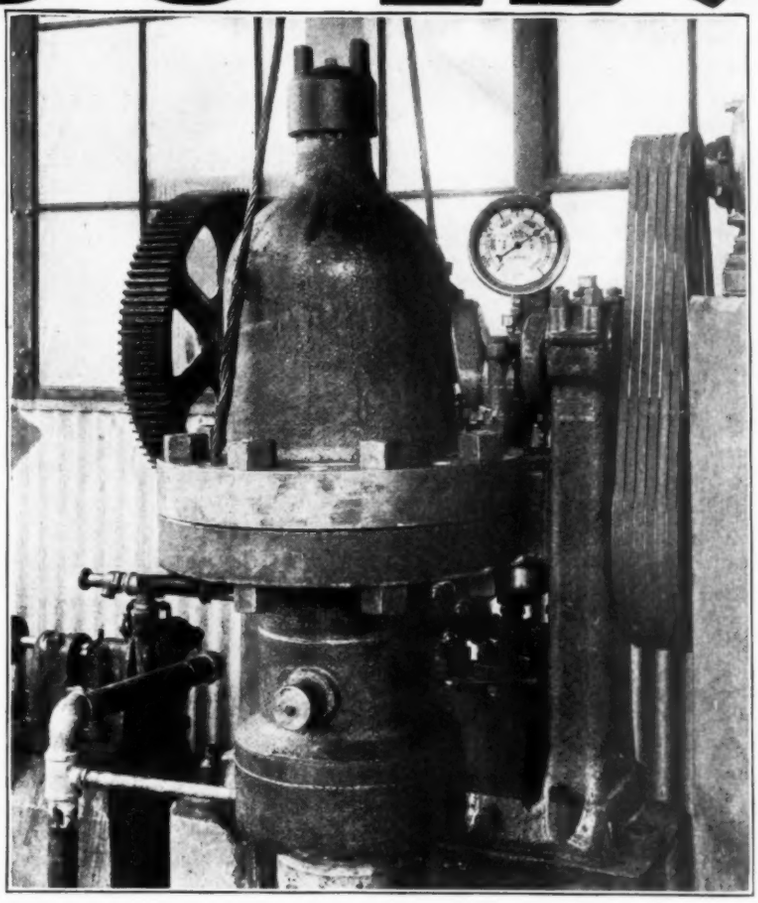

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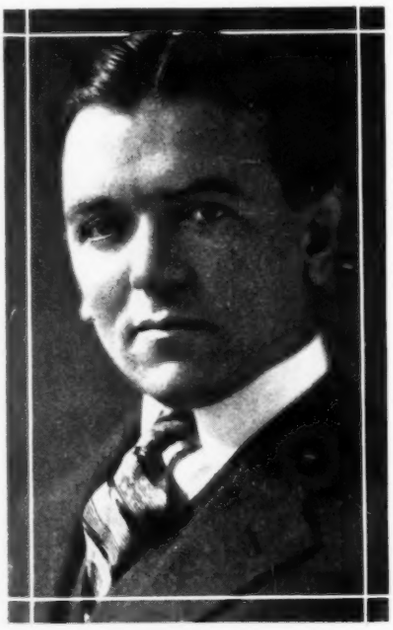
ANOTHER YEAR'S PROGRESS N

By EMBY K ly Oil

THERE has been such outstanding progress in the natural gasoline industry in recent years that as another year rolls around we expect to find in a review of the year epochal changes or discoveries. These last twelve months have wrought nothing revolutionary. This period has seen a normal development of the industry by way of growth and improvement in the manufacturing processes. Perhaps the most notable achievement has been the expansion of the by-product field to the point where considerable hope may be justly entertained that an important market has been found for one of the major components of natural gasoline, which today is a drug on the market.



Emby Kaye

Production was raised to a new peak of 6,658,064 gallons during this period. Kettleman Hills, Santa Fe Springs, Greater Seminole, Pampa and Oklahoma City fields were almost entirely responsible for the increase. In all these fields the individual plants were of tremendous size, running all the way from 50,000,000 to 150,000,000 cubic feet per day.

Due to the exceptionally high pressure of the gas at the wells, compression machinery was not required in most cases except in the Seminole. In such cases the plants could be put into operation in a short period of time and could be constructed at a considerable less cost.

Obviously, the production of the wells in these fields under back pressure has resulted in a great saving to producer and manufacturer, and royalty owner and the state. The plant is not only built more rapidly and at a lower cost, but begins the utilization of the gas at from a month to two months earlier than would be possible if compressors and appurtenances had to be installed. Moreover, the manufacturer can afford to put in a plant of larger capacity with the result that more gas is utilized from the several wells, more gasoline produced, and more residue gas sold if a market for this fuel exists. It may also be possible to obtain a natural pressure greater than that which could be justified by compression. By this means, at least as long as the excess pressure is available, a higher recovery of gasoline could be made by the plant at no cost to anyone. There are economic limits to which the efficiency of a plant may be designed, but if higher absorber pressure can be made available at no extra cost the plant welcomes it.

Plant processing has been improved all along the line. Definite limits of absorption efficiencies have been established.* The absorber of today, designed according to the best standards, will handle from 50 to 60 per cent more gas under the same set of conditions than the absorber of two years ago, while the improvements have added little to the cost of the equipment.

The separate still and dephlegmator, water-cooled, have practically disappeared from new construction and, with these, water-cooling for product control. Gasoline for reflux is now standard. This development not only makes possible closer product control, but eliminates that not inconsiderable expense occasioned by the troublesome maintenance of the water-cooled partial condensers. During the periods between descaling, end point control was invariably difficult and irregular, certainly if a high still efficiency was maintained. Unless a closed system was used, descaling tubes was a problem with the best of waters in most Mid-Continent fields. The low vapor pressures obtained today on the denuded oil were not available before in a plant running to capacity.

When the stabilizer first came into the gasoline plant it appeared as a low-pressure, low-temperature column. For some time, but particularly this last year, high-pressure

A view of Oklahoma City field with

NATURAL GASOLINE MAKING

ly Oil Company

rectification has become a standard with natural gasoline plants. The low-pressure apparatus has virtually become obsolete, and in many instances has been replaced by the more efficient pressure column. The theory and the mechanics of rectification are today a definite science, and the separation of a number of hydrocarbons to a degree of commercial purity is no longer a laboratory feat, but everyday practice in an increasing number of gasoline plants.

Not only are the various grades of natural gasolines made to given specifications by limiting the presence in those materials of propane and butane according to requirements, but, by rectification, surplus propane and butane are themselves purified to commercial specifications. Aviation natural gasoline is made by a further step in rectification by the partial removal of the pentanes. The process is continued for the separation of pentane, hexane, heptane and other groups of hydrocarbons for the yet limited but growing solvents market. Naturally, a good deal of pioneering must be done to develop the market for these new products. The growing availability of volatile gasolines at refineries through their own manufacturing processes makes this mandatory.

The bottled gas business is spreading across the country. It is drawing upon the propane supply, but it cannot become a large factor because of the small consumption per unit. The high cost of distribution will retard abnormal growth. There are several strong institutions in the business which have made enormous investments to establish an outlet for this commodity, but it is more than likely that they will use their own materials and not draw upon the open market for propane for a long time to come. How profitable this business will be even to these distributors is a matter to be determined in the future. Distribution will have to be simplified and the cost of distribution materially reduced.

The manufacturer has observed a growing demand for gas machine gasoline, aviation natural, pentanes and hexanes. Aside from aviation natural, the volumes of the other products sold are apt to be small. The bulk of the material is moving in drums l. c. l. But every little bit helps.

By far the brightest picture on the horizon is the use of butane as a substitute for artificial gas, both by industries and by small communities which cannot afford the installation of an artificial gas plant. Butane** makes possible a lower first cost, as well as a cheaper fuel for the same B. t. u. gas. It has other advantages for industry over and above price, although that alone is an important consideration. To some industries a fuel with a fixed carbon content is of the greatest importance.

As a domestic gas, partially diluted with air at a central plant, butane has all of the advantages of the usual "city gas." Due to the low installation cost for a plant of from 1,000,000 to 5,000,000 cubic feet per month, domestic gas may be made available to the small town which cannot justify the investment for a blue water gas or coal gas plant. This butane-air system has had a healthy growth in 1929 and a good deal is expected of it during 1930. Side by side with butane-air is the perfection of the gas reforming processes where butane is "cracked" and its B. t. u. reduced to 530 per cubic foot, the resultant gases made available to industry and domestic consumer. Each system has its own advantages and the interested engineer will select that process which appeals to him from the standpoint of price, safety, etc.

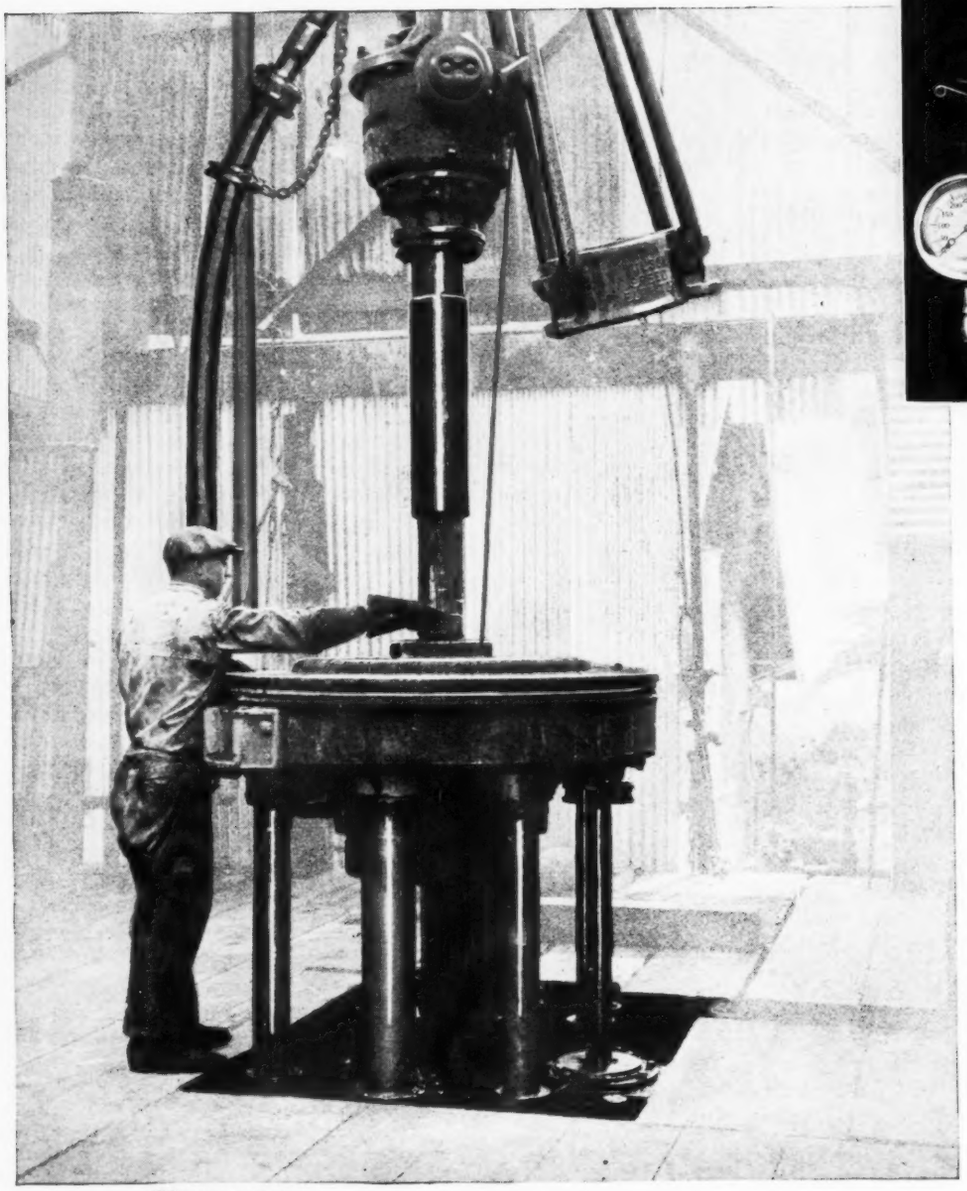
While the by-product development is interesting, it is not a panacea. This field can interest only the larger manufacturers and can interest them only in concentrated production areas. Equipment costs and operating expense cannot be justified for small situations. The greatest comfort lies in the continued improvement of the quality of the major products manufactured. While such shock absorbers as have been built by some progressive companies on the Gulf coast, to handle surplus naturals for export and East coast markets, are conducive to a more even balancing of supply and demand, the greatest expectations lie, as stated, in the finishing of natural gasolines to such specifications as will find for them a ready and natural market among the large refining industry. To such an end the natural gasoline fraternity bent its efforts in 1929 and has dedicated itself to the same task for 1930, with more than an even promise of success.

* Alois Kremser's article in California Natural Gasoline Proceedings, 1930, Volume V, No. 2, entitled "Theoretical Analysis the Key to Absorption Plant Design."

** Oberfell, Alden & Lagatzki.

a modern gasoline plant in foreground.

HYDRIL



The EXACT pressure of the bit on the formation and the EXACT amount of weight supported by the hydraulic rotary table is indicated by the Hydril Differential gage at all times. This is a pressure gage operated from the hydraulic cylinders and is calibrated to give EXACT weight readings DIRECTLY—without mathematical calculations. Mounted beside the control valves, it enables the driller to meet each formation demand with precisely the right pressure.

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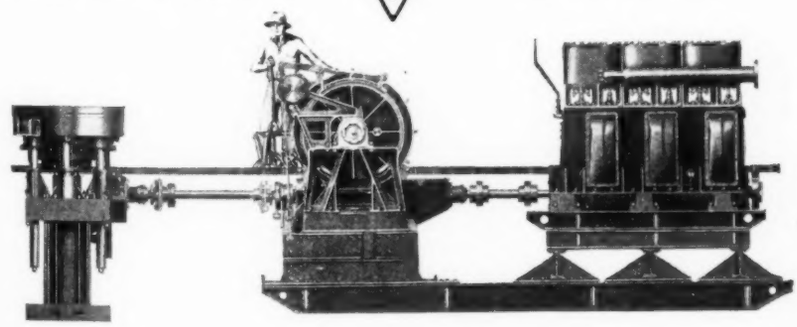

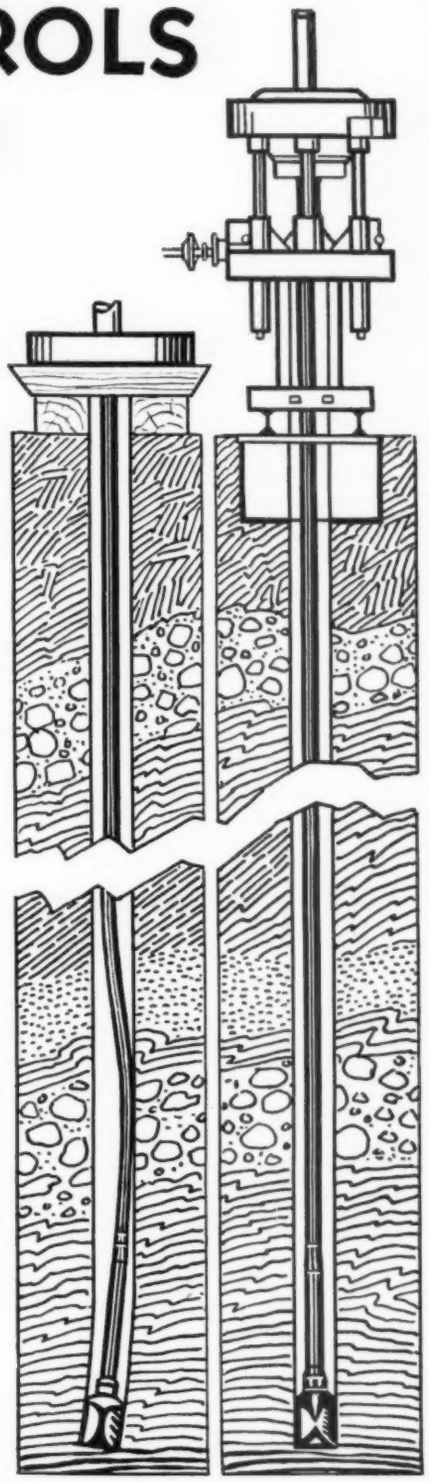

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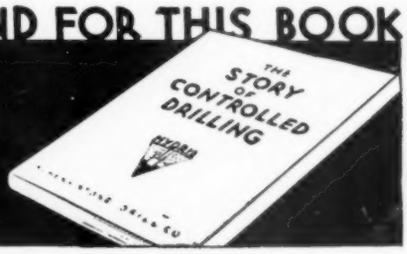

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Applying Bonding Clamps *to* Gas Lines

By B. B. LEGG[1]

THE longitudinal flow of stray direct current on pipe lines has long been recognized as one of the severest corroding agents that pipe owning companies must combat, and proper co-operative engineering with the electric railways or other systems responsible, goes far in removing or controlling this destructive force. Those working with this problem as related to underground piping systems are aware that the combination of electricity and gas, or oil, using a common carrier, has deadly potentialities from a safety standpoint; and an educational campaign is being constantly carried on with those whose duties are directly concerned with the construction and repair of the gas lines, in order to warn them of this little-known danger, and to assist them in guarding against the dangers surrounding such a combine.

When a pipe line or other continuous structure having a current of appreciable value moving upon it is severed, the tendency is for a spark to be created between the separated parts. The intensity of the spark will depend upon the current density of the conductor, the difference in voltage between the separated parts, and to an extent upon the condition of the severed ends, particularly where the structure is a gas pipe.

The workman's experience and the methods used in joining or cutting the pipe in the trench will be contributing factors and may tend to increase or decrease the attendant risk. It follows that an inexperienced crew, finding it necessary to fumble a joint in removing it, is increasing the risk by a series of make-and-break contacts which invites, if current is present, a number of sparks, any or all of which may be sufficient to ignite leaking gas.

In communities having electric railway service, the danger is more acute if a pipe line, having screw, welded, or other metal to metal joints, is the structure under construction or repair, due to the smaller electrical resistance of joints of this type, and the consequent easier path offered the flow of current. Nor are the transmission and production lines far removed from electric railway tracks exempt from the flow of stray current. Transmission lines, due to their size and length, often collect from the earth and conduct a large amount of stray current, relatively speaking, and, because of their remoteness from trolley operations, are apt to give a repair crew a false sense of security.

Particularly is this true in localities where coal mines are operating small electric mine cars and other equipment. Here the source of current is even less apparent and often affects wells, production lines and transmission lines over a large area.

With the safety factor in mind, the Columbia Engineering and Management Corporation, Gas Engineering Department, has developed the device shown in Fig. 1 for the purpose of providing another path for the current, allowing it to be shunted around the separated pipe ends.

It should be noted here that the principle of the device is not original, but the newer design supplants the old cumbersome, fairly complicated compression screw tool, or the practice of filling the pipe and wrapping wire around the cleaned portion which is highly unsatisfactory.

These newer bonding clamps, as they are called, are constructed of saw steel with small machined points inserted. The clamps are faced with copper straps bent slightly more than the steel in order to insure good contact between the

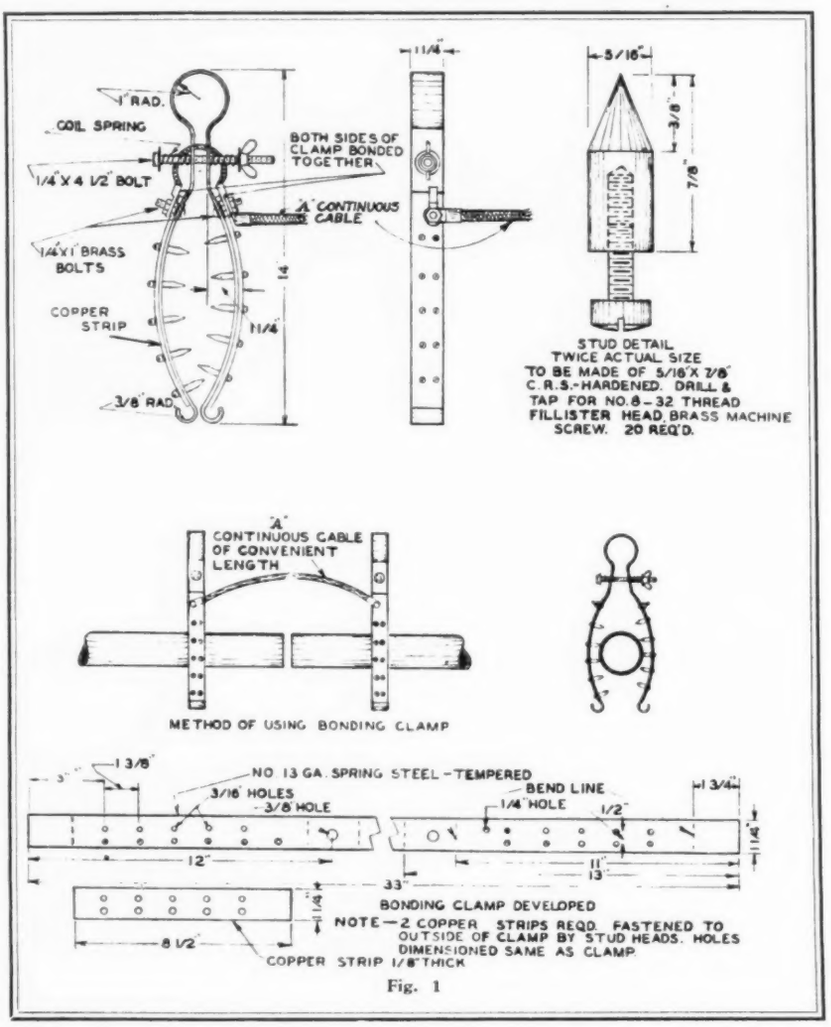

Fig. 1

[1] Gas Engineer, Columbia Engineering & Management Corp., Columbus, Ohio.

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EXPANSION and contraction of pipe lines is often a serious problem with standard wrought pipe. Expansion joints are often necessary, thus adding materially to the cost of the line.

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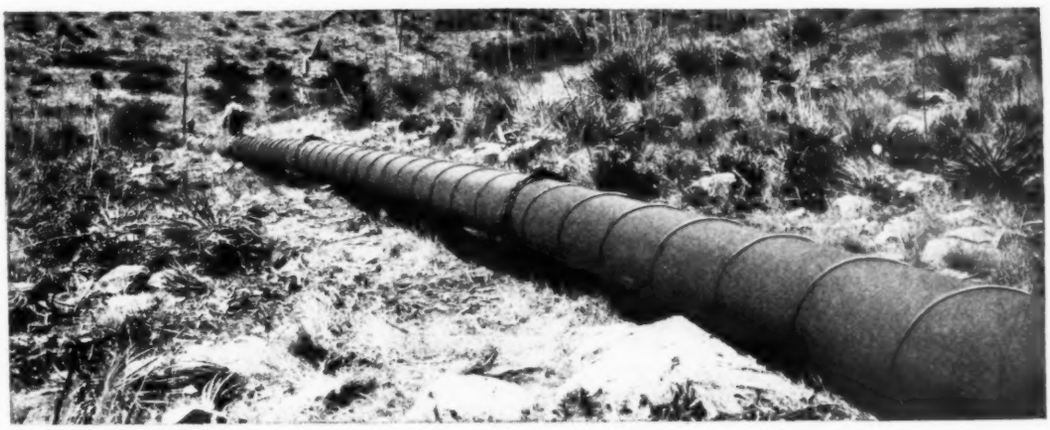

A 16-inch Naylor Pipe line, 30 foot joints, Victaulic coupled, laid on desert in West Texas. Note the absence of expansion joints.

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screw heads and the copper, in addition to forming a lock for the screws.

Before inserting the contact points, the screws which hold them in place were first dipped in solder and the surplus removed by dropping them on the work bench.

The design of the clamps provides a path for the current from the pipe through the contact points to the soldered threads and thence, via the copper straps and connecting cable, to the companion clamps and out by the same path to the pipe.

This forms a low resistance shunt circuit for the pipe current which, under ordinary circumstances, is sufficient to reduce the difference in potential between the separate structures and prevent to a large extent the tendency for a spark to be formed at any point on the structure spanned by the two clamps.

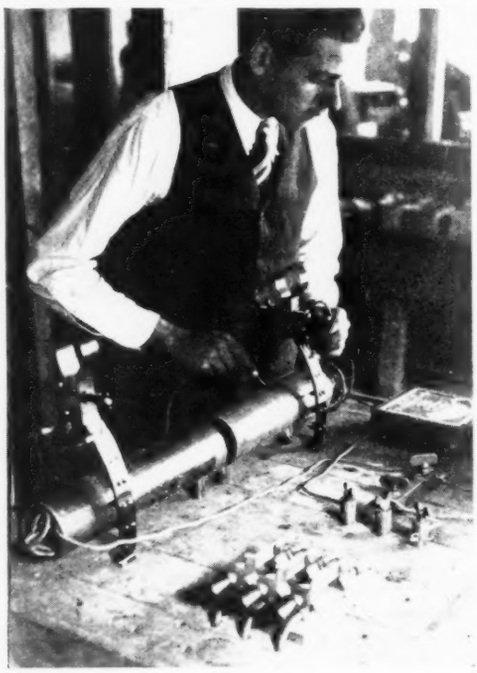


Fig. 2—Laboratory testing, observing current and voltage characteristics.

Laboratory and Field Tests Conducted

Tests were conducted (Figures Nos. 2 and 3), and some of the results obtained with the clamps in use are as follows:

1¼" Steel Pipe—60 Amperes—No Spark.

3" Steel Pipe—60 Amperes—No Spark.

3" C. I. Pipe—60 Amperes—No Spark.

6" C. I. Pipe—60 Amperes—No Spark.

Combinations were tried using different current values and varied applications of the clamps and under no combination was the slightest spark obtained.

The clamps, being primarily self-adjusting, are easily placed on a pipe spanning the point where a cut is to be made or where a connection is to be completed, and each clamp is rocked back and forth slightly in order to allow the hardened steel contact points to penetrate any high resistance coating covering the metal.

Practical Use of the Device

Figure 4 shows the clamps in use for low pressure main work. A number of the different jobs to which the device is applicable is as follows:

1. Low pressure mains. Connecting, disconnecting or cutting pipe.
2. High pressure mains. Transmission or production lines.
3. Connecting or disconnecting service pipes from low or high pressure mains.
4. Changing piping design of regulator or meter settings.
5. Installing or removing domestic meters where an additional risk is encountered through alternating current leaks.

Miniature clamps, easily carried in the pocket, may be made for the meter men and for those working on service pipes.

It is seldom necessary to use the clamps when working on pipe lines that have couplings using the rubber ring under compression or bell and spigot joints sealed with cement, as a series of these joints are sufficient in combined electrical resistance to reduce collected currents to minute quantities of small weight in the present problem, although of sufficient value at times to be of importance in a corrosion investigation.

Conclusion

The facility with which these clamps of any size may be applied, their light weight and ease of transporting, have recommended their use to the field crews and will go far in reducing a risk that may result in serious accidents involving personal injury claims and property damage.

It should be remarked that the usual currents found on piping systems are of such small quantity, the voltage values being correspondingly small, that little danger may be anticipated from electric shock, the greatest risk being unconfined gas and an electric spark which may form a frequent combination in practice unless properly guarded against.

Fig. 3—Field testing the clamps for use on different size pipes.

Fig. 4—Safety bonding clamps in place preparatory to cutting pipe.

Developments in

Flowing Production Through Tubing

By H. C. OTIS[1]

THE past year has seen in both cable tool and rotary fields a steadily growing tendency toward the use of tubing, of either straight or tapered design, in the handling of flowing production. This tendency is toward not only the increased use of tubing in this connection, but also toward its more intelligent use, and is indicated by the large number of experiments now being conducted.

A year ago it was the practice in some few rotary fields to bring wells in through tubing, and thereafter to allow the well to produce only through the tubing. In almost every instance wells thus handled produced their oil with considerably less gas wastage than other wells in the same fields flowing through the casing and controlled only by surface chokes. This evidence was enough to convince many operators of the desirability and efficiency of this method of operation. Lack of actual comparative information on individual wells, uncertainty as to flow levels and as to tubing design were, however, factors which caused other engineers to hold back in recommending tubing programs. Too, the bringing of wells in through tubing in some areas was frowned upon by production superintendents because of the uncertainty not only as to the volume of the well to be handled but because of the uncertainty as to properly cleaning out behind the liner. The tubing of large-volume, high-pressure wells in cable tool areas could be accomplished, if at all, only at great risk and considerable expense.

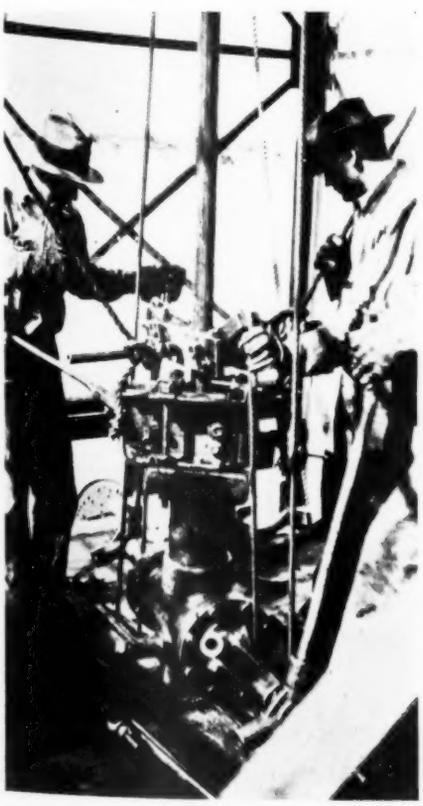
In spite of these handicaps, interest kept on increasing. Papers read at the Tulsa A. I. M. E. meeting last fall, at various A. P. I. meetings and others published in the trade journals all indicate the amount of thinking and discussion that is going on. That question—the use of tubing—is probably today uppermost in the minds of the majority of production superintendents and petroleum engineers. Almost all engineers, and a good many production departments, are convinced as to its desirability where gas is the flowing agent, and where the tubing string is properly designed. The matter of tubing design, however, is in its infancy; much more remains to be learned than has been learned so far.

The development within the past year of equipment which permits safe installation of tubing against pressure, without loss of production and without interrupting or disturbing the feed of the well, has given an impetus to the whole movement. Comparative experiments are now being made in the same well. Records as to gas-oil ratios with no tubing in the well, and later with tubing of one design, then another design, are being made. A great deal is being learned—enough to indicate that a great deal more remains to be learned.

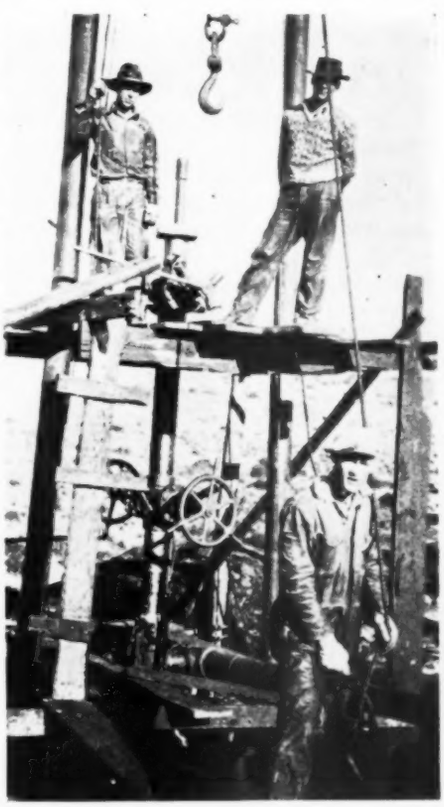
The Yates (Texas) field is furnishing an ideal laboratory for these experiments. Well volumes in this field are large, gas is the principal flowing agent, and the field is under an intelligent close proration. The shallow depth at which production is found—1600 to 1800 feet, dependent upon surface elevation—together with comparatively low working pressures of 200 to 600 pounds, tend to low costs of experimenting.

Work was started the latter part of last December when a tapered string of two, three and four-inch tubing was run into a 35,000-barrel well under 600 pounds pressure. The landing

H. C. Otis is one of the most widely known gas production engineers in the southwestern territory. For many years he has been identified with this phase of the industry in the Louisiana and Arkansas territory and it was soon after joining the staff of the Arkansas Natural Gas Corp., at Shreveport, that he gained much prominence as a result of developing a method of tubing large gas wells under pressure.

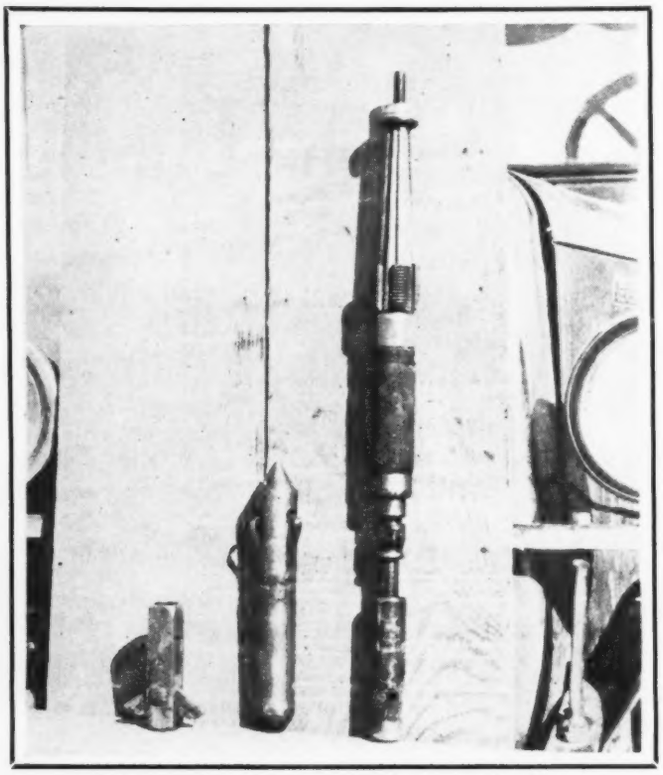


Detailed view of derrick floor with big well being tubed.



Snubbing tubing into a well in Yates Pool, Texas.

[1]Arkansas Nat. Gas Corp.



Tools used for drilling out plugs in bottom of tubing.

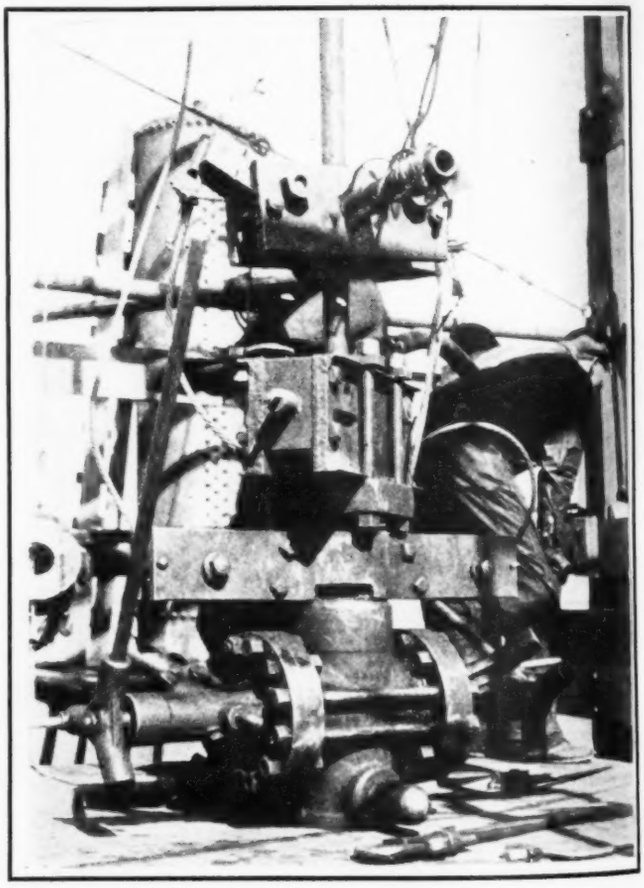
of such a string — probably the first of its kind ever run against pressure—without the loss of a gallon of oil was in itself quite a mechanical feat. The results obtained, however, were equally interesting. The former gas-oil ratio of 1863 cubic feet per barrel was reduced to 245 cubic feet, and, still more surprising, the official prorating potential capacity test of the well, taken with both the tubing and casing open, showed an increase of approximately 50 barrels per hour. While delighted with the results obtained, the official in charge was not satisfied with the gas-oil ratio, since the theoretical quantity of gas which should, under those conditions, be used in flowing a barrel of oil is about 145 cubic feet. Eleven wells for that company in that field were tubed with either straight or tapered strings. Three different tubing designs were tried in one well, the tubing being plugged on bottom and snubbed out through control heads in the same manner in which it was run in. Results obtained at first were not in all cases satisfactory. In the instance of one well, a tapered string of two, one-and-one-quarter and one-inch—a string which had given excellent results in several other wells—actually caused a gas-oil ratio almost double that obtained through casing alone. Replacing this string with three, two-and-one-half- and two-inch with packer, however, remedied the trouble. The lowest ratio obtained in any of the wells was 163 cubic feet per barrel—certainly a remarkable figure.

Other companies, seeing the results obtained, are taking up and continuing these experiments. One company, with a large number of wells in the field, has divided its wells into five classes. In two wells, each typical of its class, it has had run straight strings of two-inch tubing with and without bottom hole chokes; in a well typical of another class it has had a string of straight one-and-one-half-inch tubing installed; in another, one and one-quarter-inch; while in the well typical of the fifth class it has had a tapered string of two, one-and-one-quarter- and one-inch installed. It is their plan, after results have been observed for 30 days, to have these strings pulled and the designs changed for another 30 days. Another company has an ingenious plan of running two-inch tubing, inside of which is run either a partial or complete string of one-inch, depending upon conditions. Still another company has standardized upon straight strings of two-inch and has within the past few days contracted the installing of such a string in every well it owns in the field.

It is too early to give in detail the results obtained, and to forecast the results to be obtained in the future. Gas-oil ratios have been decreased on the average probably 75 per cent, increased potential capacity is shown in a large number of instances, a longer flowing period is bound to result, and increased ultimate production is hoped for. In addition, the wells which are tubed, since they are flowing off bottom, should indicate more quickly than those not tubed, the encroachment of water. It is anticipated that the majority of the wells in the field will have been tubed by fall.

While operators in the Yates field have during the past year probably taken the lead in this type of experimenting, others too have shown an interest. Tubing strings of various designs have been run in Oklahoma; a string of two, two-and-one-half- and three-inch has just been run in a 46,000-barrel well in Kansas. Plans are being made for an experimental installation in Oklahoma City, and for similar work in the Lea field in New Mexico. Gulf coast operators are discussing the matter. Inquiries from the western states and from foreign fields are being received by the contracting company which is making a specialty of handling tubing under pressure. All this interest which is being shown and these experiments which are either in progress or are planned for the near future speak well for further developments during the coming year.

The work is still so new that not all of the equipment necessary for complete tubing service has as yet been per-



Running tubing in a big well at Oklahoma City.

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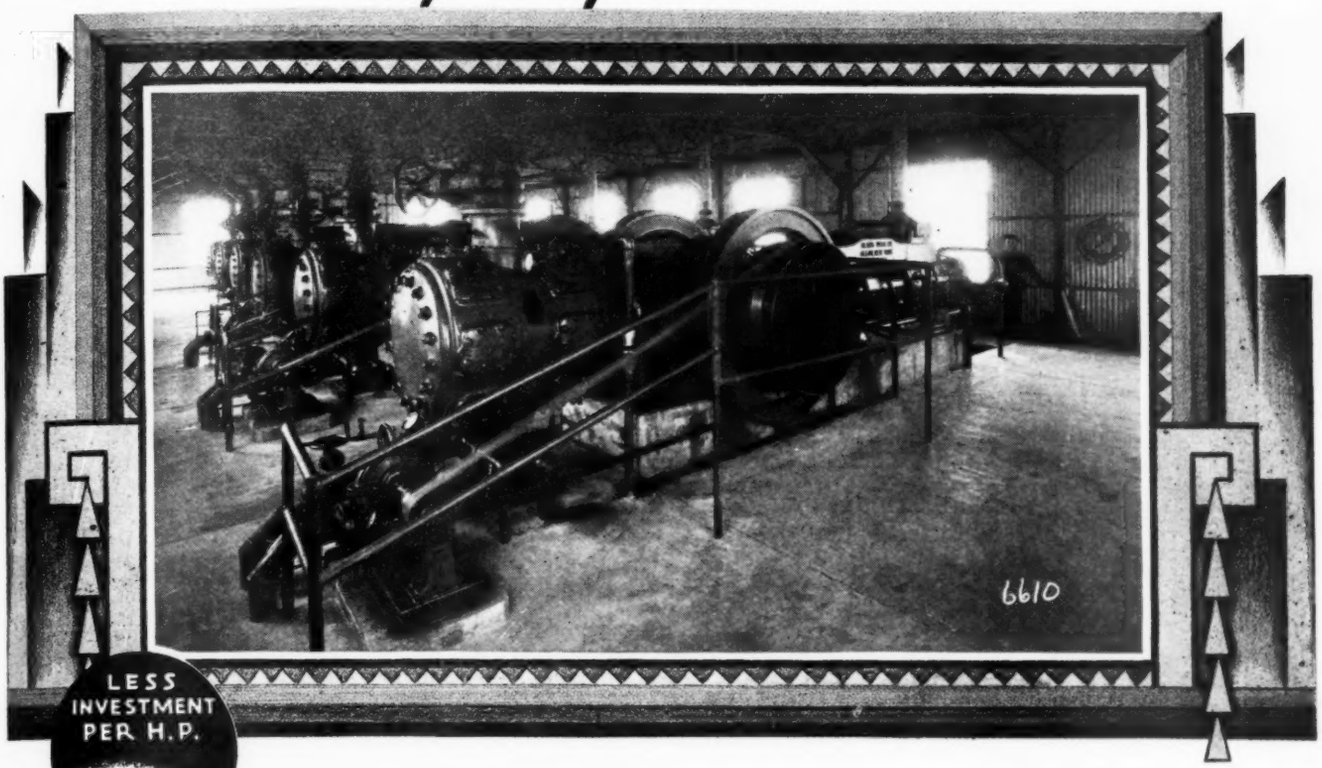

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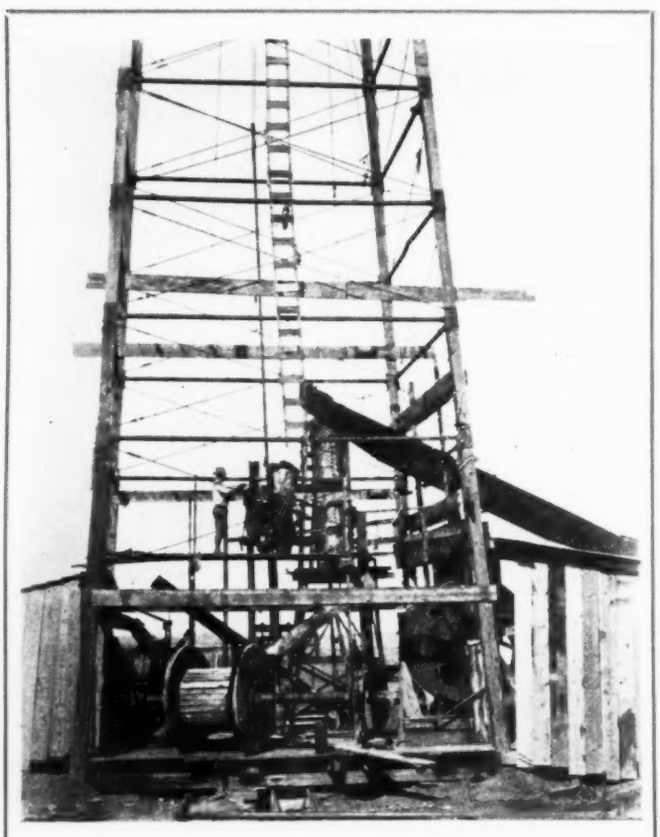
fected. One piece of equipment which had been lacking was a device to permit the easy raising and lowering of tubing in a flowing well without loss of production—this to allow the finding of the most efficient flow level. This piece of equipment has, however, now been perfected and will shortly be put in use. Another device still lacking is some method of definitely determining fluid levels outside of the string of tubing while the well is flowing through the tubing. Still another is a pressure bomb which will indicate bottom hole pressures while the well is feeding through tubing. These devices are now being experimented with and it is hoped that within another year more in the way of mechanical equipment necessary for the study and accomplishment of this particular work will have been developed.

Rigging up on a difficult location in West Texas.

The value of bottom hole chokes, or flow beans, in this work is still to be determined. Here, too, development has been handicapped by the lack of equipment which would permit of easy and cheap experimenting. A flow bean which can be run and set on a wire line running through a stuffing box, and which can be pulled out of the hole in a similar manner has recently been devised. Before long the efficiency to be obtained by choking tubing at the bottom of the string as compared to choking it at the top will have been determined.

Certainly the last year's developments have indicated that the most desirable method of prorating the production of a field is a method which involves the use of tubing—probably an agreement to flow continuously through tubing of agreed diameter combined with a choke similarly agreed upon would constitute the best method. This method would permit continuous 24-hour operation of wells, would result in approximating the full efficiency of the gas, would undoubtedly prolong flowing life, and would probably increase ultimate production. The difficulties resulting from the use of methods of curtailment employed in the Seminole and Oklahoma City fields can, it would seem, be easily avoided.



Tubing a cable tool well.

There has been enough data gathered to indicate what should be obvious — that the lowering of gas-oil ratios through the proper use of tubing prolongs the flowing stage of a well's life. There are also enough examples of wells so handled as compared to offset wells not so handled to definitely indicate considerably increased ultimate production. The whole movement is, however, so new that there has not been sufficient time in which to gather data that will permit forecasting, in the instance of any one field, just what effect in barrels of ultimate production can be expected. There are instances, too, which indicate the effect in retarding the encroachment of water — but here again much has still to be learned.

The use of tubing in the operating of high-pressure gas wells has not been mentioned so far. Gas operators have taken up this method of operation even more quickly than have oil operators. Throughout the Mid-Continent field there is a growing tendency no longer to regard a gas well as properly completed until after it has been tubed—this for two reasons. One is, of course, to assure the handling of fluid from the very start. The other is to have the tubing to serve as protection in event of casing failure after the well completion. This is of extreme importance, especially in high-pressure rotary fields, where in the event of casing failure after completion, the well must first be killed before repair work can be started. During the past two years in the Richland field, Louisiana, two wells cratered after completion because these wells had not been tubed and because men and equipment were not available for immediate tubing. Three other wells in that field in which casing failure developed after completion were saved because men and equipment were available for immediate tubing. The other tendency is toward the use of tubing—or siphons—of sufficiently large diameter to permit withdrawing through the tubing not only the fluid made but also the well's normal gas production.

In brief, the past year has seen a rapidly-increasing interest in the handling of high-pressure gas and of flowing oil production through tubing. A tubing service which includes the safe running and pulling of tubing in wells of this sort that has been made available to the operators has allowed for experimenting in tubing design in individual wells. These experiments so far have indicated that properly-designed tubing strings will, where gas is the flowing agent, accomplish a great deal in the conserving of this gas and in the all-around better operation of the well. They have indicated, too, that through the use of properly-designed strings the wide-open capacity of the well can in some cases be increased.

Portable Drilling Rigs

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When moving, a minimum of break-down and set-up time, as well as difficulty in transporting is required. Rigs are built in sections which may be quickly and easily dismanteled and hauled on an ordinary oil field truck. As each unit or section is complete on a substantial base, proper alignment is maintained regardless of the number of times the rig is moved. These units are tied together and made rigid by special turnbuckles.

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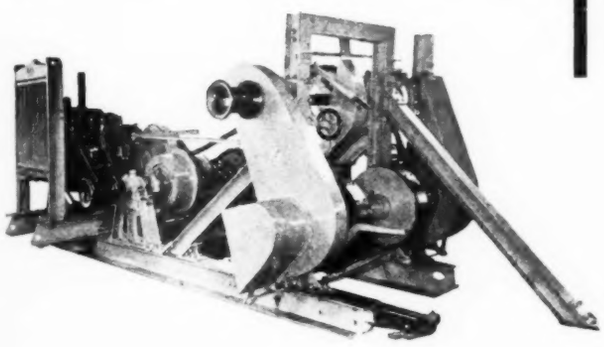


Illustrated above is our Three-Speed Draw Works Unit. This entire Unit is mounted on one structural steel frame, and in moving from one location to another it is not necessary to tear down the Draw Works. This Rig is designed for use in connection with any size or type of derrick desired and can be furnished with 60, 75, 100 or 125 h.p. engine to suit customers' requirements. It is built entirely of steel. Write for Bulletin No. 200.

5000 FEET

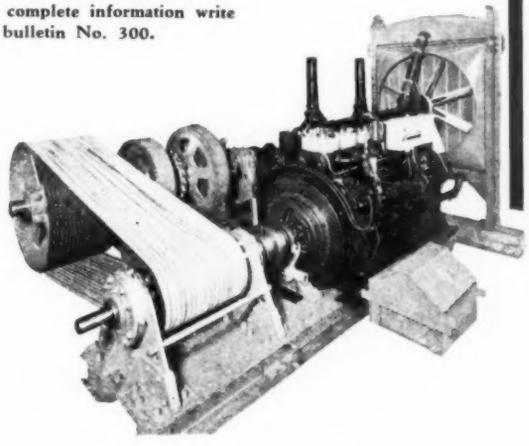
The 5000-ft. Rigs are made in two types—Extra Heavy Duty (upper illustration), powered by a Waukesha Great Six 300 H. P. engine, and the Heavy Duty (lower illustration), powered by two 125 H. P. Waukesha engines.

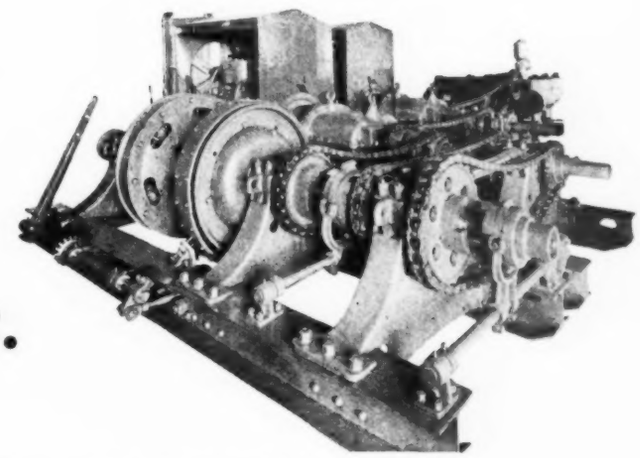
On the Extra Heavy Duty Rig, power is transmitted by Texrope drive to reverse clutch unit, thence to drawworks by means of split-type sprocket. The reverse clutch unit is all-steel construction, operating on both Timken and American Roller Bearings. Reverse clutch is oil bath type with steel cut gears and hardened pinions.
While it is designed for 5000-ft. depths with 6-in. drill stem, it has gone deeper in several cases. Bulletin 300 gives complete details. Write for it.

The Heavy Duty Rig consists of 4 sections, viz.: Two engines, pump and reverse clutch, mounted separately and easily moved on ordinary oil field trucks.
In the hook-up pictured the power of either or both engines, singularly or simultaneously, can be used to drive the slush pump or diverted to the drawworks, as desired by the operator.

The reverse clutch unit is equipped with three steel clutch sprockets to drive from the engine unit, through which three distinct speeds are secured to line shaft on drawworks. This rig is designed for depths to 5000 feet with 4-in. drill stem. There are instances, however, of it having gone considerably deeper.

For complete information write for bulletin No. 300.





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Equipment and Method Used for Testing Anti-Knock Value *of* Motor Fuels

By H. J. ROBERTSON, *Chief Chemist;* G. W. HADLEY, *Testing Engineer; Pierce Petroleum Corp.*

NEW equipment for testing the anti-knock value of motor fuels was recently installed by the Pierce Petroleum Corporation in their refinery laboratory at Sand Springs, Oklahoma. There are several novel features with respect to this apparatus and the method of operation that should be of interest both to the manufacturer of motor fuels and the motoring public.

Essentially, the equipment is simply part of a lighting plant and consists of a single cylinder engine mounted with and directly connected to a 1500-watt 32-volt direct current generator, designed to operate at 1,800 r.p.m. The engine is of the "L" head type, cylinder 2⅞ inches diameter, piston stroke 4 inches. A number of alterations were made on the engine prior to its installation, the most important of which was replacement of the original head with a specially designed head containing a movable piston which was placed in the head directly above and in alignment with the engine cylinder. This piston was of the same diameter as the power piston. The upper part of the piston shaft, its brace and its special type of packing unit may be seen in figure one directly over the engine. It was found necessary to use this special steam fitting type of packing unit in order to prevent combustion chamber leakage at the higher compression ratios. The upper piston is actuated by a screw mechanism and the volume of space in the combustion chamber is calibrated for every position of the upper piston. From this, the compression ratios at various positions of the piston are determined and a vertical scale attached to the piston brace allows this piston to be set at any compression ratio desired. The use of the movable piston thus installed permits variation of the compression ratios from 3.5 to 1 to 7.5 to 1. Although a compression ratio of 7.5 to 1 is not as high as compression ratios obtained by some other fuel testing installations which have been described in the literature, yet this ratio has been found sufficient for all gasolines that have been tested in this laboratory. In fact, very few of these gasolines have reached a compression ratio on this machine of over 6.5 to 1 before a drop in power is noted.

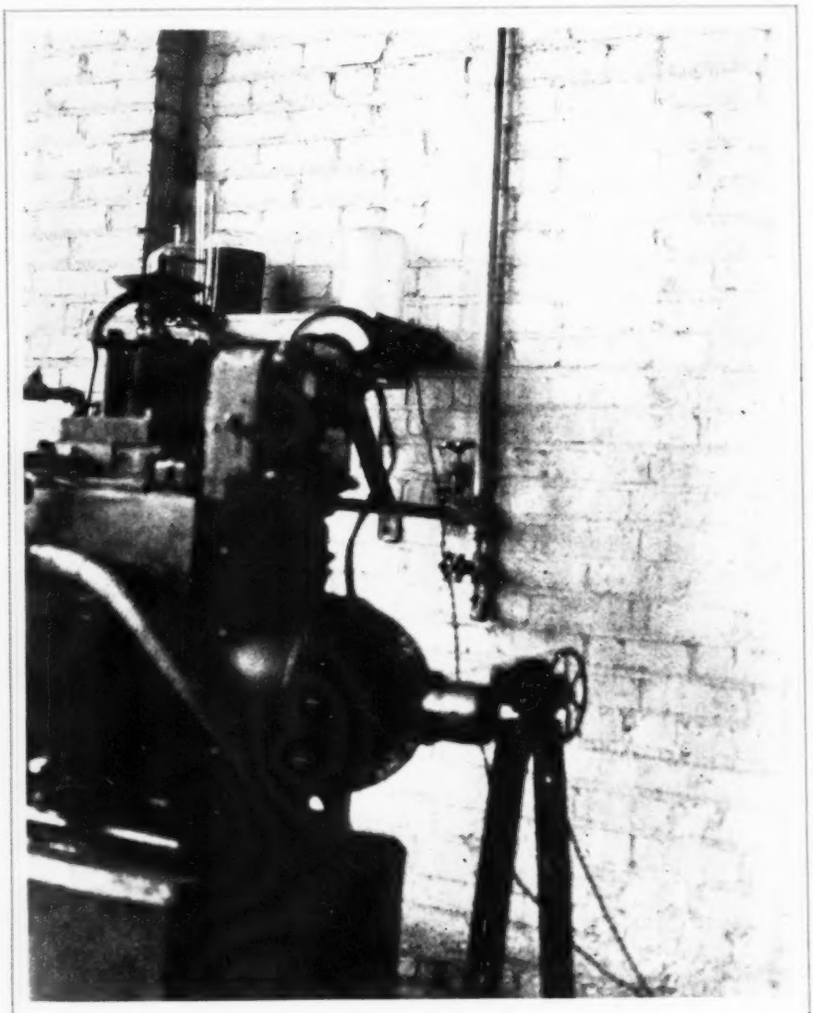

Fig. 1

The cooling water is taken directly from the refinery water main and is heated by the engine exhaust gases before entering the water jacket, from which it is allowed to escape as steam, thus maintaining a constant water jacket temperature of 210 degrees F.

The engine is fitted with a Zenith carburetor, which as originally furnished was not adjustable, since a definite jet size is provided with each engine. This made fuel-air adjustment impossible and gave some very erratic results until the carburetor was altered by drilling a ⅛-inch hole in one of the jets and fitting this jet with a small needle valve. The air used in the carburetor is preheated by the exhaust gases of the engine. The generator set above mentioned is used for loading the motor, the current generated being taken up by a number of coils, each of one Ohm resistance. The number of coils in the circuit at any one time may be varied at the panel board, illustrated in figure 2 at the right.

On the panel board, besides the control switches for the resistance bank, are indicating instruments consisting of an ammeter and voltmeter, also an integrating watt meter which registers total watts generated. In addition to these instruments an indicating tachometer is installed on the engine and is operated off the generator shaft. All of the instruments are of the Weston type; the ammeter and voltmeter are especially adapted to this particular installation inasmuch as the scale has unit divisions permitting the operator to read even fractions of a unit, thus permitting very

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delicate adjustment and precise determination of the actual power produced. The tachometer was mounted on the engine instead of the panel board for convenience since in the former position it is more readily observed by the operator. It is desirable to know the speed of the engine (which is an indication of the power developed) at all times.

There have been various methods proposed by which to determine the critical point, i. e., the point at which the fuel begins to knock, such as by bouncing pin, audible knock, maximum power developed, etc. There has been some objection on the part of various investigators to the use of the bouncing pin and audible knock methods of determining the critical point. These objections will not be discussed here; suffice to say, a standard method on which the majority of investigators would agree has not been agreed upon up to this time, although considerable work is being done toward that end and the final method that is universally adopted may be more or less of a combination of the above. The highest compression ratio at which maximum power is developed with any gasoline would appear to be a measure of its true anti-knock value because any interference with the explosion, such as a detonation knock, would tend to decrease the amount of power developed, other things being equal. This is along the line of work done by Ricardo and others. In the installation, the subject of this article, the determination of the critical point by the bouncing pin method was impractical and the determination by audible knock was not possible because of the high speed at which the engine is operated, being approximately 1,600 r. p. m., at which speed the knock cannot be accurately determined because of the noise arising from other parts of the machine. There was also some objection to this method due to the fact that a listening method depends more or less upon the ability of the operator to distinguish certain sounds and this ability differs with different individuals.

Generally speaking, in operating this apparatus the throttle adjustment is set for constant speed and the fuel-air ratio is varied to develop maximum power. The spark adjustment is set for maximum knocking conditions and is not varied. Water temperature is maintained constant. The power developed is read from the ammeter to within as close a determination as possible while maintaining a constant voltage. In testing the fuel, as the compression ratio is stepped up, the power output gradually increases until a point is reached when there is a drop in the power curve. This point is taken as the indication of the engine knock. To obtain consistent results, it has been found necessary to allow the engine to warm up by operating it for a period of about two hours, at the end of this time the fuel to be tested is switched to the engine. This change is made by means of clamps at the aspirator bottles containing the gasoline, illustrated on the shelf at the top of figure 1. The time required for the new fuel to reach the engine is decreased by the use of a drain in the line at a point near the carburetor. The engine is allowed to run on the new fuel for a period of five to ten minutes or until a constant power output is obtained. The compression ratio is then increased to a point where further increase fails to raise the power output of the motor. At this position the fuel-air ratio is set for maximum power and the compression ratio then lowered to a ratio of 4.5 to 1. All readings are obtained at this compression ratio and at every .5 to 1 increase thereafter with additional readings taken immediately both before and after the power drop. Thus a compression ratio causing the power drop and the amount of this drop is known and can be compared with results obtained when using a standard test fuel. In most cases it is found that the power output will remain constant for a short period of increasing compression ratio before it starts to decrease. The standard fuel used in these tests is the straight run Mid-Continent gasoline of approximately 430-437 end point. This fuel is regarded as equivalent to zero anti-knock value. This is blended, as is the usual practice, with various percentages of commercial benzol in order to get values comparable with the fuel being tested.

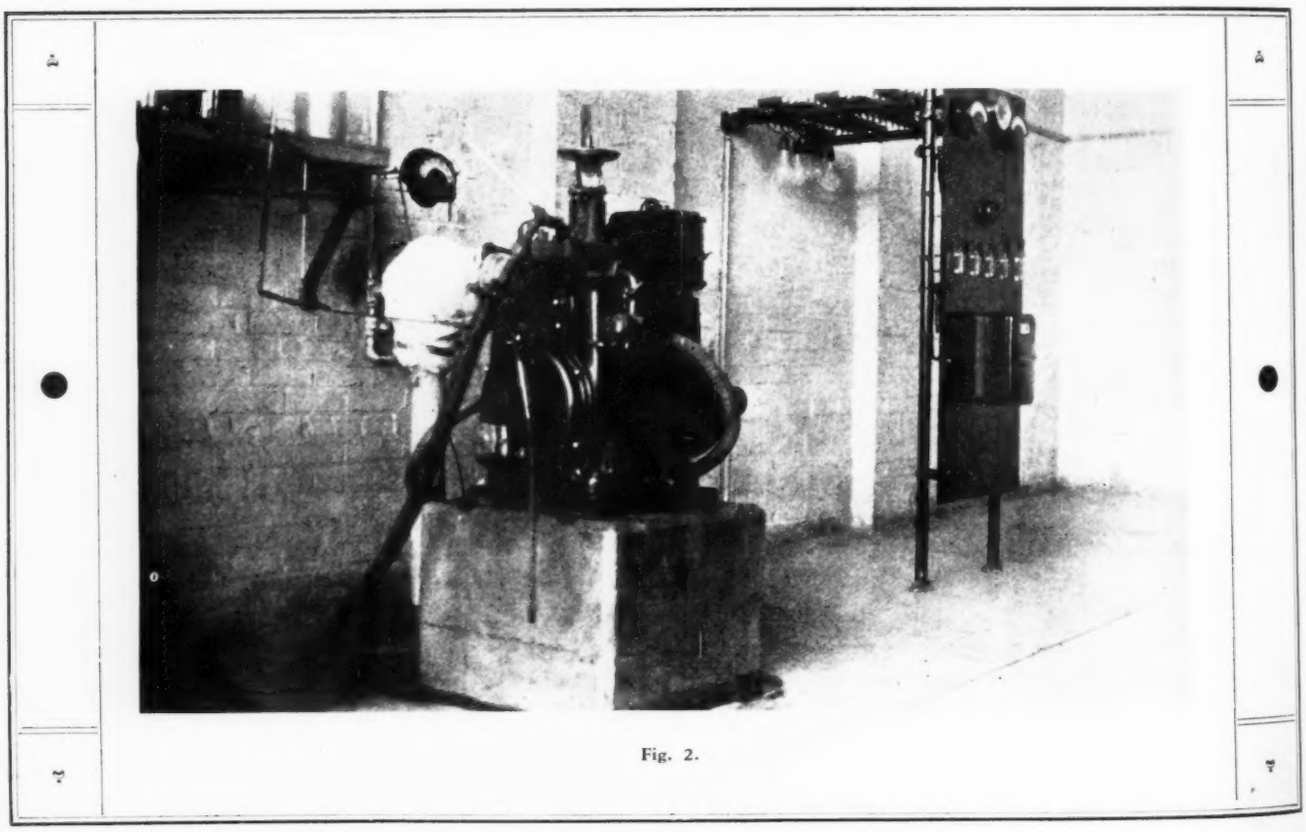

Fig. 2.

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The Development and Trend in » » Refinery Distillation Equipment

By C. M. RIDGWAY, *Supt. Old Dutch Refining Co.*

THE year 1929 probably witnessed the installation of more modern fractionating units than any other year in the history of the petroleum industry and from all indications the year 1930 will eclipse that record. What might be termed the modern era in the refining industry began about 1920. Each succeeding year has seen greater changes and more intensive application of sound engineering and economic principles than the preceding year, and the movement appears to be gaining in size and momentum. Intensive competition and economic reasons have been the contributing factors, although the development of the modern combustion engine has been responsible to a certain extent for the application of modern distillation equipment to the production of lubricating oils.

Primary Distillation

The batch still or continuous battery can no longer be considered for the topping or primary distillation of crude oil. Not only is this true of new installations, but many of the progressive refiners find that they cannot afford to operate continuous batteries which are all ready in operation when all of the factors are taken into consideration. A few of these factors are: Elimination of re-running, more flexible and unified operation, greater yields of the more valuable products, lower losses and lower steam and fuel consumptions. The trend is toward the single flash type of apparatus due to the inherent advantage of single flash vaporization over the differential flash. There are, of course, certain conditions that require a double flash operation, but in the majority of cases the single flash is superior.

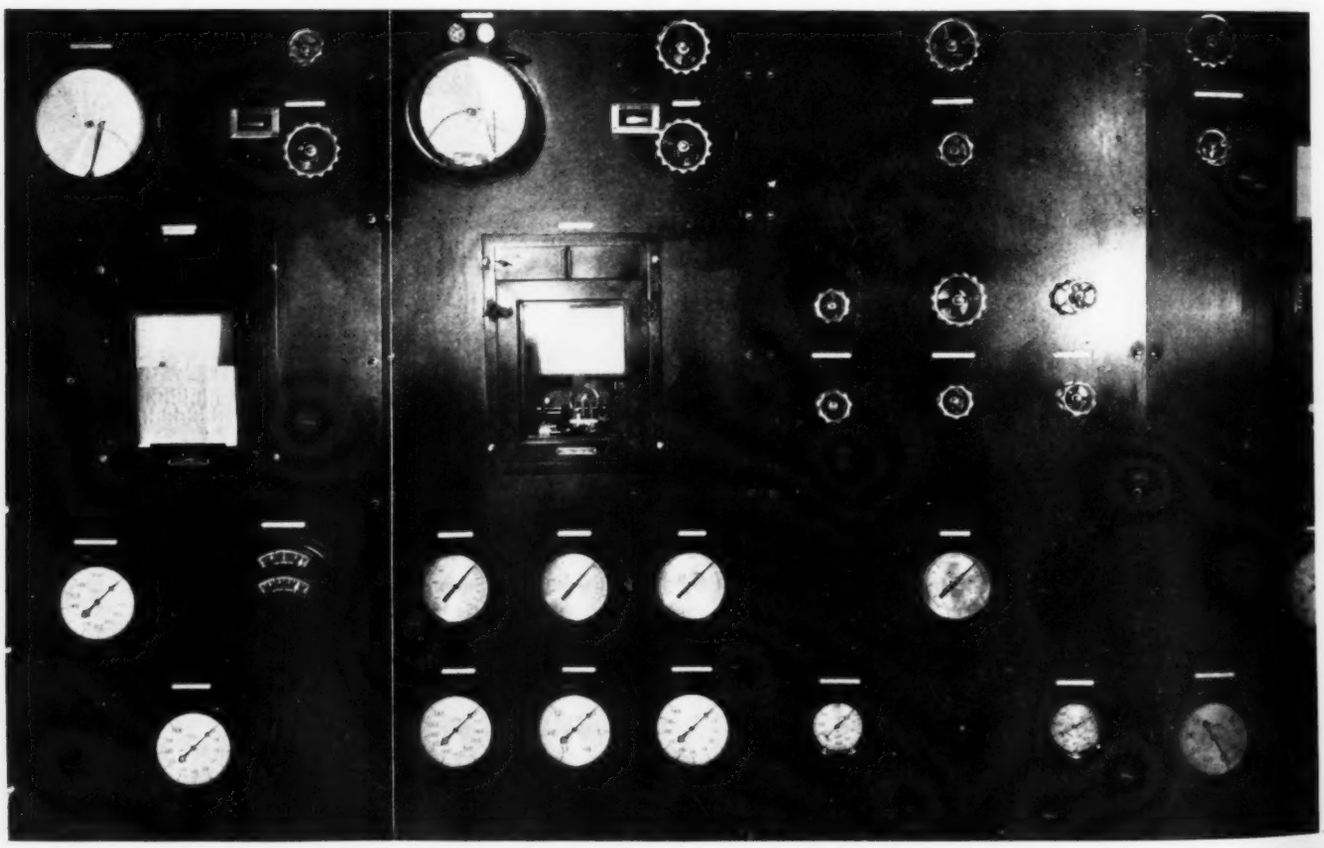
The capacity of the individual units is increasing and at the present time single units capable of processing 15,000 barrels of crude oil per day are in operation. The large volume per unit materially reduces the operating cost per barrel as is illustrated by the following costs:

Capacity	Operating Cost Per Bbl.
3,000 bbl/24 hrs.	$0.126
5,000 bbl/24 hrs.	.111
12,000 bbl/24 hrs.	.089

Cracking

Where it is desired to produce only straight run gasoline, kerosene, cracked gasoline and fuel oil, the tendency is toward the combination topping and cracking unit. In an efficiently designed unit of this type, the waste heat from the cracking operation is usually sufficient to flash off the straight run gasoline and kerosene. The crude after being heated to the proper temperature by heat exchange is flashed to remove the gasoline and kerosene, the reduced crude being transferred to the cracking operation where the cracked gasoline and fuel oil are flashed in a separate fractionating column. This type of installation is more economical to install and operate than those where topping and cracking are carried out as two separate operations.

Cracking units are now being equipped with efficient fractionating columns and those that are operating in conjunc-



Instrument Board

tion with either suitable vapor phase or other treating methods are making end point gasoline which does not require re-running. The ensuing year will no doubt not only see a more extensive use of fractionating columns, but will also witness the application of stabilizers to cracking units so that the product coming directly from the unit will be a stabilized marketable motor fuel.

The pipe still cracking units operating with and without reaction chambers are rapidly being improved, resulting in longer operating cycles, excellent yields, low maintenance costs and relatively low installation costs. Data obtained from units now in operation indicate that yields can be increased considerably by intelligent design without sacrificing long operating cycles.

One rather interesting development in the art of cracking is flashing the cracked residuum to specification pitch under vacuum, the distillate being returned to the cracking unit as recycle stock. This method of operation has interesting possibilities, more particularly in the processing of mixed base and asphaltic crudes. There is no doubt but that several of these units will be in operation by the end of 1930.

Overhead Lubricating Stocks

The manufacture of overhead steam refined stock for the preparation of bright stocks is rapidly gaining favor. This has been brought about by the decrease in the amount of good steam refined crude available as compared to the market demand in the Mid-Continent area, the necessity for decreased operating costs, and the ever increasing demand for lubricating oils of better physical properties. Probably the chief factors have been the necessity for decreasing costs and competitive market conditions. Two lines of light colored, low carbon residue, low volatilization loss motor oils prepared from paraffin base crude have been announced and several more will soon be on the market.

Rerun Distillation

The pipe still unit is gaining favor for all types of rerun operations. This is due to the fact that many of the refiners have discovered that they can not afford to operate shell stills or continuous batteries in this service when all of the savings that can be realized are taken into consideration. This is more particularly true in the distillation of pressed distillate, centrifuge solution and pressure distillate.

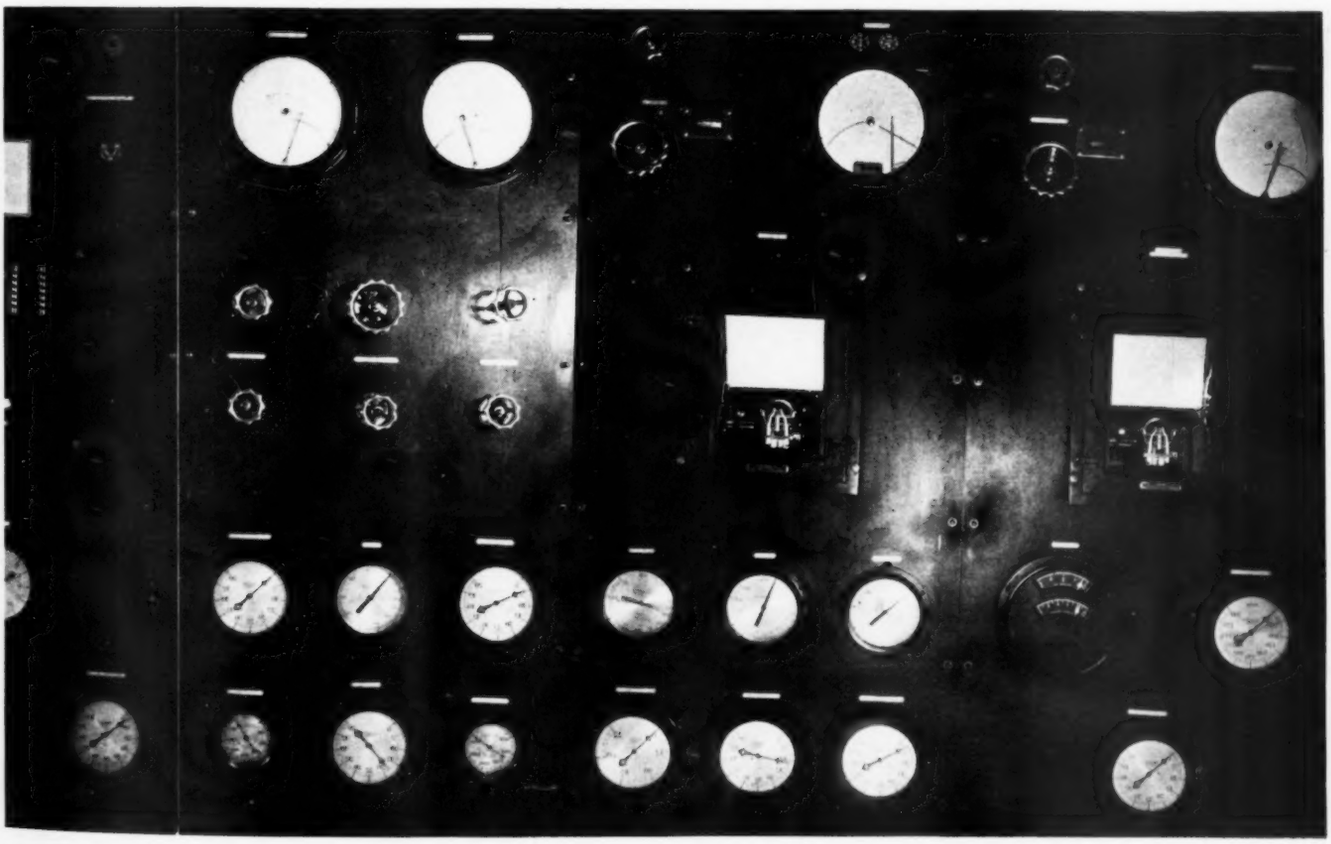
In the distilling of lubricating stocks the chief advantages of this type of equipment are:

(1) Decreased fuel and steam consumption.
(2) Decreased distillation loss.
(3) Increased yields of valuable lubricating stocks.
(4) Better color and low carbon residues.
(5) Increased flash for a given viscosity.
(6) Elimination of the necessity for re-running any of the distillates.

Where pressure distillate is being distilled in pipe still units the refiner has found the following advantages:

(1) Decreased fuel and steam consumption.
(2) Decreased distillation loss.
(3) Increased yields of gasoline.
(4) Improved color stability and lower gum content.

When we think of the great strides which have been made in the refining industry during the past few years we are tempted to feel that the ultimate has been reached. However, we only have to consider the changes in refining methods that have occurred in the last two years to realize that such is not the case. As an example, less than two years ago some of the manufacturers of pipe still heaters advertised the use of tubes shielded from radiant heat, whereas, today the more efficient types of heaters remove 70 per cent of the heat absorbed by the oil from the fuel in the form of radiant energy. No doubt the refiner of 1880 felt very complacent when he compared his plant with those refining "rock oil" on the banks of Oil Creek in the 1860's and we should be prepared for even greater changes in the next few years.



in a Modern Refinery

ADDING A NEW OUTLET

When writing MIDWEST PIPING & SUPPLY CO. INC., *please mention The Petroleum Engineer*

MIDWEST
PASSAIC
ST. LOUIS
HOUSTON
The combined pipe fabricating capacity of the four Midwest plants far exceeds that of any other organization in the country.

THE artist has caught the important fact that the new pipe fabricating plant now beginning operation in Houston is an integral part of the Midwest organization. And as suggested by the similarity of the nozzles, the Houston plant is another complete and modern shop well-equipped to fabricate piping for all purposes.

Users of fabricated piping outside the area served by this new plant at Houston will also benefit. Its establishment enables each of the four Midwest plants to offer the advantages and economies of production on an even larger scale* and of an increased purchasing power. It makes possible additional development to improve piping practices and more extensive research to anticipate the piping requirements of tomorrow—work that a smaller company could not profitably undertake.

The builders and operators of power plants, oil refineries and industrials who have used Midwest Piping Service know it to be unhampered by tradition—know it is the Midwest Policy to simplify and improve piping wherever possible and that substantial savings have resulted in many instances.

Now, even more than ever before, it is advantageous to get in touch with the nearest Midwest office whenever fabricated piping is required.

MIDWEST PIPING & SUPPLY COMPANY, INC.

Main Office—1450 So. Second St., St. Louis

Chicago, 208 S. La Salle St.
Los Angeles, 520 N. Anderson St.
Houston, 600 Bringhurst St.
Tulsa, 733 Mayo Building
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THE GREATER MIDWEST PIPING SERVICE

Control Devices for » » » »

Electrical Pumping Equipment *in* California

By R. N. McMASTER*

THE Torrance Oil Field is located approximately 20 miles south and slightly west of metropolitan Los Angeles, and of the numerous producing areas in the Los Angeles basin is by far the largest, being approximately seven miles in length by 1½ miles in width.

The area was first brought to the attention of the oil world when the Chanslor-Canfield Midway Oil Company started drilling operations in February, 1921, on its well, Del Amo No. 1, which well, in June, 1922, was brought to completion, marking the addition of another oil field to the already numerous fields of California.

Practically all of the major producing companies of California are represented in the Torrance area, the two largest in point of producing wells at this writing being the Chanslor-Canfield Midway Oil Company and the Standard Oil Company, these two companies operating 50 per cent of the producing wells.

Table 1 is an interesting comparison of wells being operated by various companies in the Torrance field as of April 15, 1930.

Very early in the development of its Torrance holdings the Chanslor-Canfield Midway Oil Company became convinced of the desirability of using electric power for drilling and producing, and, as the development of these properties progressed, it was found that a complete system of power distribution would be desirable.

At this writing the C. C. M. O. Co. has between 25 and 30 miles of such lines, energy being transmitted over a 3-phase, 4-wire, 4000-volt "Y" connected system, which in turn is served by the Southern California Edison Company's 3-phase, 16,500-volt distributing system. Transformer equipment, consisting of two banks of 3-1,000 k. v. a. transformers each, is furnished and maintained by Edison Company.

Five circuits serve the Chanslor-Canfield Midway Oil Company properties, all radiating from its substation, where ample equipment is provided for circuit metering, testing, switching, protection, etc. (Figure 2).

Inasmuch as a large portion of the C. C. M. O. Co. properties are in large blocks of acreage, it was found that secondary transformer banks could be readily arranged to serve 8 to 12 wells each, the 440-volt secondary leads being delta connected, and usually not exceeding 1200 feet in length. A very large percentage of these transformer banks consists of 3-50 k. v. a., 2,300/440-volt transformers.

Soon after the installation of the oil company's distributing lines it was found, by careful analysis of Edison Company power schedules, that a well worthwhile saving in power costs might be effected through the use of a schedule based on maximum demand and energy charges only and not considering connected load.

Almost from the first day's use of electric power, tests were being made to determine the most economical operating conditions, and to perfect devices to be used in that connection. Brief descriptions of some of these devices will be given here.

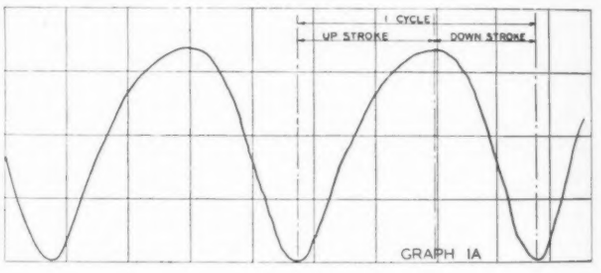
Because of the rapid decline of Torrance production, it was early seen that some method of pumping other than the arbitrary "head well" method might be of great advantage. To that end an automatic electric intermittent pumping control was devised wherewith the pumping of a well could be controlled, the total "off" and "on" cycle being 100 minutes.

Tests using this device were first made on well Del Amo No. 93, where under continuous pumping over a nine-day period an average daily production of 19.29 barrels of oil was had, with an average power consumption of 133.33 k. w. h. per day.

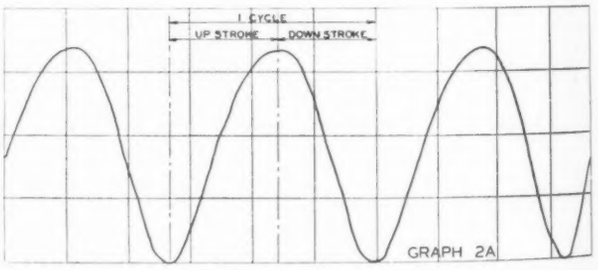
After considerable experimenting with the intermittent control device as applied to this well, the correct time was found to be 50 minutes pumping and 50 minutes idle. Under this "50-50" combination, on a nine-day test run, the average daily production was 19.50 barrels of oil with a power consumption of 51.11 k. w. h. per day, or a direct saving in power consumption of 62 per cent, with a very slight increase in oil.

This device is entirely feasible and pays excellent dividends, as the cost of installation is comparatively small. It is now in operation on wells Dominguez Nos. 1 and 2 (two outlying wells) and controls the pumping of the two wells, each well pumping alternately one hour while the other is idle. In order to avoid the possible overlapping of the pumping loads, there is a small time interval between the shutting down of the first well and the starting of the second.

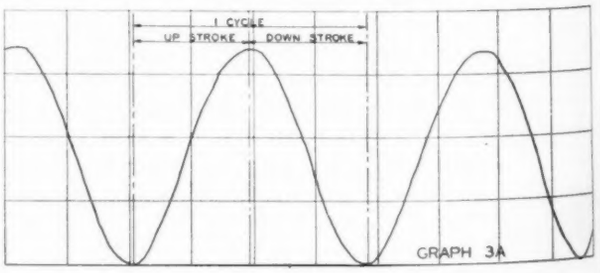
In making tests with this intermittent device it was found



GRAPH 1A



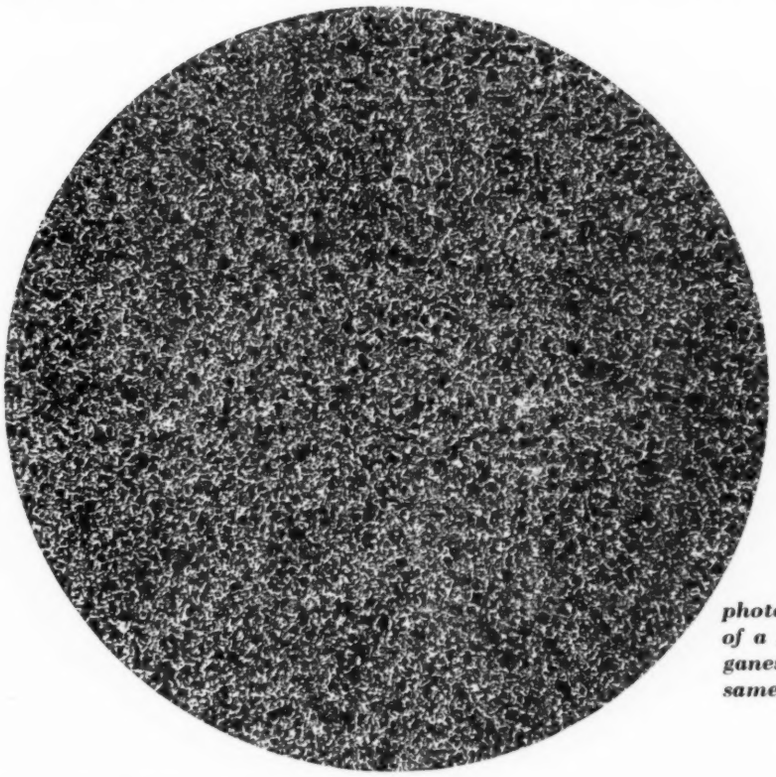
GRAPH 2A



GRAPH 3A

* Chief Engineer, Chanslor-Canfield Midway Oil Company; Associate Member, American Society of Civil Engineers.

EXCLUSIVE PHYSICAL PROPERTIES THAT MAKE



This is a micro-photo of the structure of a Jones High Manganese Rod, and it is the same—from end to end.

JONES *High Manganese*
SUCKER RODS

THE WORLD'S PREMIER RODS FOR DEEP AND DIFFICULT PUMPING

A Tensile Strength of 115,000 to 120,000 pounds per square inch

As compared with ordinary sucker rods having a 75,000 to 100,000 pounds per square inch employing a good grade of commercial steel. This high tensile value is due to the fact that Jones Rods have less carbon and more than double the manganese content of ordinary rods.

An elastic limit of 70,000 to 80,000 pounds per square inch as compared with 40,000 to 60,000 in ordinary rods.

These comparisons give an excellent idea of the plus value and extra service built into every Jones High Manganese Steel Sucker Rod.

The alloy steel used in these super rods was compounded with the utmost skill with the assistance of some of America's best known Metallurgists.

The result is the Jones High Manganese Fully Normalized Sucker Rods combining a perfect balance of tensile strength with toughness assuring maximum endurance and service for the deepest wells of today.

THE S. M. JONES COMPANY

TOLEDO, OHIO

Mid-Continent Office: McBirney Building. Tulsa, Okla.

When writing S. M. Jones Co. *please mention The Petroleum Engineer*

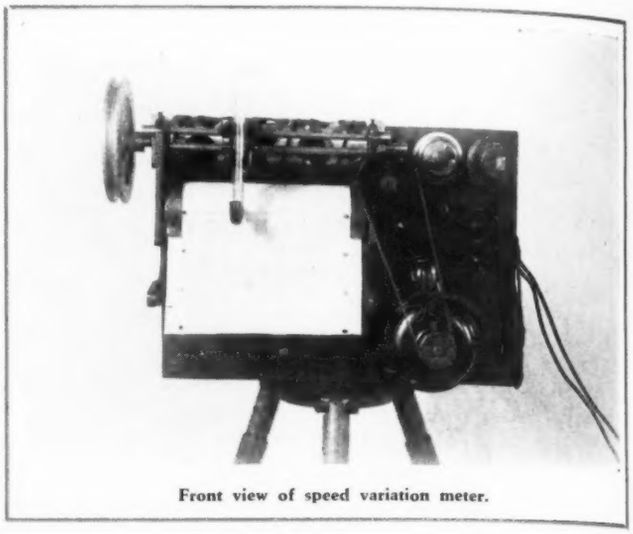
that each well required a separate and complete study, and for that reason the device was not considered adaptable to general use.

In the opinion of the writer, the theory of intermittent pumping is sound, as with comparatively short "off" periods the hydrostatic head of the column of fluid is maintained at or very near a uniform minimum, with a consequent lessening of back pressure on the producing sands, and a consequent increase in production per unit of pumping time.

The same results are obtained, however, through the newer development of "slow motion pumping" for which standard pumping equipment may be used with only slight changes. For this arrangement a small nine-tooth sprocket is substituted for the larger sprocket, thus allowing the 15/35 h. p. pumping motor to operate on the ninth controller point, consequently eliminating control grid losses which accompany operation on lower points of the controller. In addition to the substitution of the small sprocket, a so-called "dishpan" sprocket of the same size as the sprocket displaced by the small nine-tooth sprocket is furnished each well gang. This "dishpan" sprocket slips onto the reduction gear shaft, fits over the smaller nine-tooth sprocket, and is bolted to it. The "dishpan" then being properly aligned with the band wheel sprocket, the drive chain may be replaced and pulling proceed.

Previous to the installation of the nine-tooth sprocket, pumping speeds had been approximately 20 strokes per minute; after the change this was reduced to seven strokes per minute, with results as shown in Tables 2 and 3. These tabulations summarize, for two wells, pumping operations for six months, both before and after the slowing down of the pumping action.

It is to be noted in these tabulations that under slow-motion pumping, the installation cost of the nine-tooth sprocket has been included, consequently an even more gratifying saving might legitimately be expected for the second six-month period of slow-motion pumping.



Front view of speed variation meter.

The protection afforded by this device was two-fold—it would not allow the pump to be started with a closed suction or on an empty tank, the "no pressure" contact being so designed as to require the attendance of the pumper until sufficient pressure was created to raise the gauge needle from the "no pressure" contact. Also, upon emptying the tank the pump discharge pressure would drop, the pressure gauge needle would contact the "no pressure" terminal and the starter would be tripped. Similarly, an "overpressure" or "overload" contact would cause the tripping of the starting mechanism where pressures became excessive because of a closed discharge valve, plugged line, etc.

In endeavoring to handle field shipping at a minimum power cost, it was found advisable to limit pumping, as much as possible, to the hours between 11 p. m. and 6 a. m., as any maximum demand created between these hours was not used by the Edison Company in computing the monthly power bill. A close observance of this rule resulted in monthly savings of from $100.00 to $200.00.

In any plant utilizing electric power it is agreed that a certain fire hazard exists from possible short circuits, and to eliminate such hazards, so far as possible, the "ground detector" was devised.

Because of the wiring arrangement on field transformer banks (ungrounded delta) it would be possible for one leg to be grounded, with no damage resulting until one of the

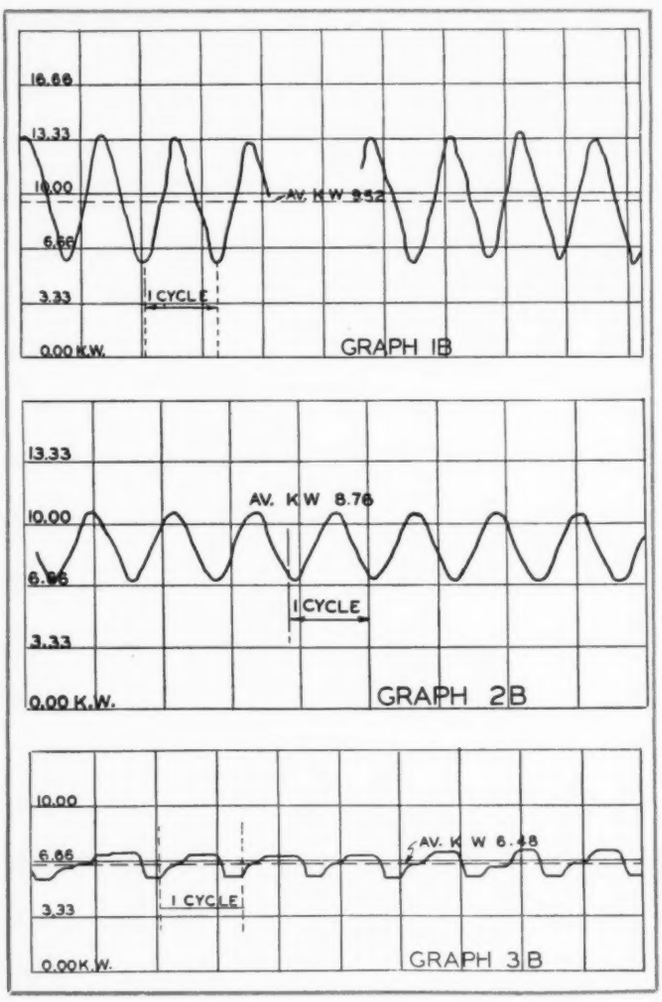
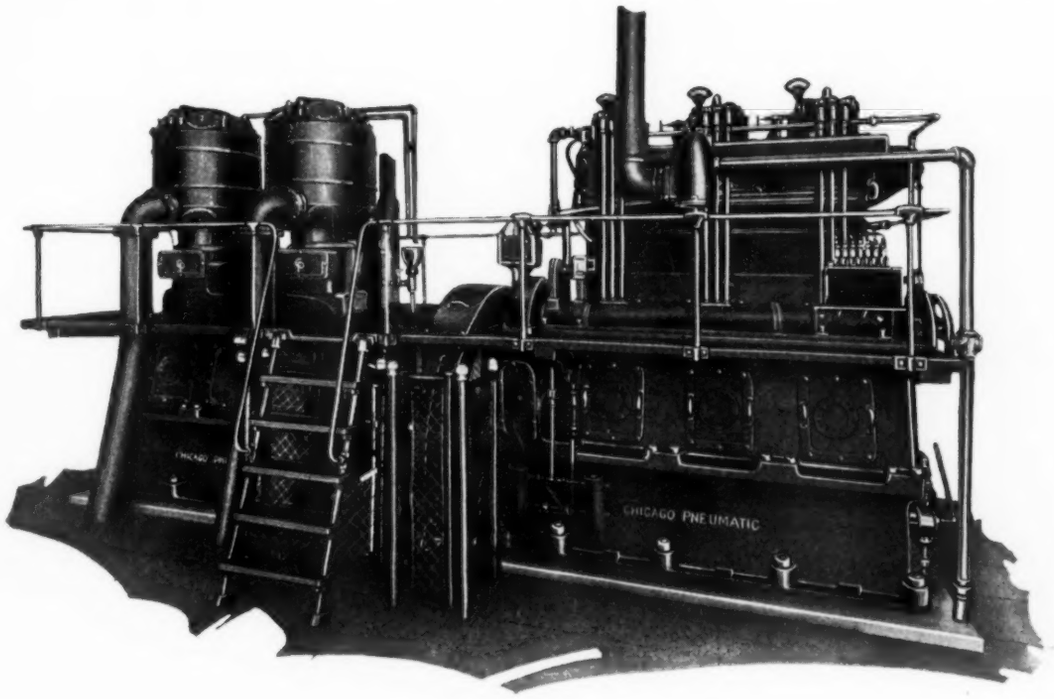


TABLE I.

Summary Showing Ownership of Producing Wells in Torrance Field as of April 15, 1930.

	No. Wells Producing	Per Cent
Chanslor-Canfield Midway Oil Company	158	28.37
Standard Oil Company of California	119	21.37
Shell Oil Company	52	9.33
Superior Oil Company	48	8.62
Pacific Western Oil Company	39	7.00
The Texas Company	24	4.31
Fullerton Oil Company	17	3.05
General Petroleum Corporation	15	2.69
George F. Getty, Inc.	12	2.15
Miscellaneous and Scattering	73	13.11
Total	557	100.00

A Modern Compressor for Gasoline Extraction and Oil Field Service



THIS is an ideal combination of a 200 B.H.P., vertical, three-cylinder, four-cycle CP Gas Engine, directly coupled to a CP vertical, duplex, double-acting compressor for gasoline extraction, gas boosting and general oil field service. The unit offers the following outstanding advantages:

1—Ease of installation.

2—Small and inexpensive foundation.

3—Small floor space.

4—Smooth operation with minimum of vibration.

5—High overall efficiency, the gas consumption being only 9 cu. ft. per B.H.P. hour at full load.

6—The engine is heavily built and can be converted for Diesel operation where the gas supply becomes inadequate.

7—A large number of compressor cylinder sizes is available for pressures of 25 to 1,000 pounds.

8—All engine and compressor cylinders have removable liners.

9—Compressor discharge valves are on the bottom and the cylinders are self-draining.

10—Force feed lubrication for all cylinders and bearings.

11—All engine valve cages are removable. The exhaust valve cages as well as the exhaust manifold, are water cooled.

12—A device is provided for stopping the engine if the lubricating oil supply fails.

May we send you complete details?

C-286

Chicago Pneumatic Tool Co.

6 East 44th Street, NEW YORK, N. Y.

Sales and Service Branches all over the World

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other two legs was grounded. The ground detector, through suitable relays, etc., is designed to indicate the partial or complete grounding of the first leg, thus allowing the

A—Small 9-tooth sprocket. B—Dish-pan sprocket. C—Bolts for attaching.

repair of this failure before serious damage arises through the grounding of the second leg. The device has shown itself on test to be entirely reliable, and is so designed as to flash a red light, sound a horn or otherwise call to the attention of the attendant the fact that a ground has developed. For testing purposes the unit has a test and reset arrangement whereby the attendant may at any time check the installation to assure himself of its proper functioning.

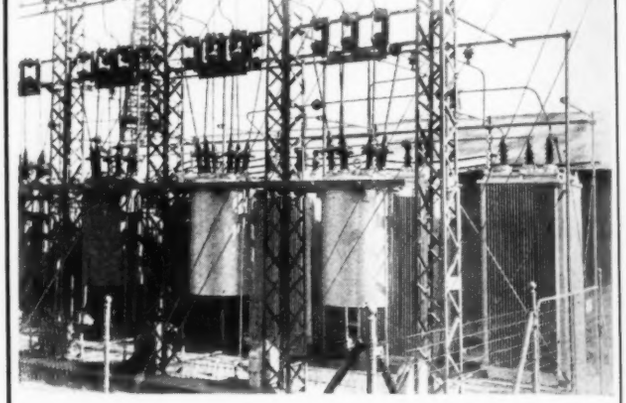
In the design of this device it was planned to provide for the installation of a complete unit at each transformer bank. Before proceeding with the numerous installations necessary, it was deemed advisable to make a series of tests, using the original instrument as a test set. This was done, with the result that a considerable number of grounds of varying intensities were discovered and repaired before any damage arose.

As is evident by the number of mechanical devices on the market, the problem of counterbalancing, in oil well pumping, is of considerable importance. To obtain as nearly correct counterbalancing as possible, the speed variation meter was designed, with very gratifying results. The device is actuated through a cord wound around the grooved pulley, the upper end of which is attached to the polished rod by suitable clamp, with the lower end holding a small weight.

Graphs 1A, 1B, 2A, 2B, 3A and 3B show results obtained using the speed variation meter in conjunction with a graphic wattmeter, the "A" graphs being from the speed variation meter and the "B" graphs from the wattmeter, both taken at the same time.

Using each pair of "A" and "B" graphs together, the power saving is readily determinable as the balancing of the up and down strokes of the rods approaches equality.

Graphs 1, A and B indicate an under-counterbalancing of 12 per cent, with an average power input of 9.52 k. w., or 12.76 h. p. With an added weight of 700 pounds (making total counterweight 2100 pounds), this under-



Switching and transformer equipment serving C. C. M. O. Co.'s Torrance properties.

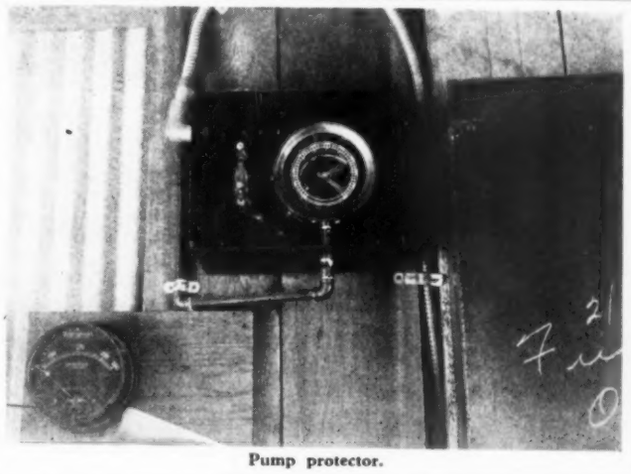
Table 2.
Comparison of Pumping Methods
Chanslor-Canfield Midway Oil Company
Well No. Kettler 1

Month and year	Net Prod.	Days Prod.	Labor Material Cost	Power Cost	Total Upkeep Cost	Lifting Cost Per Bbl. Power Only	Total Lifting Cost Per Bbl.
Pumping 30-tooth sprocket 19¾ strokes per minute							
1929							
April	483	30	$ 257.89	$ 70.98	$ 328.87	$ .147	$ .681
May	474	27	335.26	66.03	401.29	.139	.847
June	339	29	307.13	71.34	378.47	.210	1.116
July	205	20	381.14	60.56	441.70	.295	2.155
August	397	25	345.30	60.05	405.35	.151	1.021
September	383	29	242.36	36.64	279.00	.096	.729
Totals	2,281		$1,869.08	$ 365.60	$2,234.68	$ .160	$ .980
Pumping 9-tooth sprocket, 7 strokes per minute							
1929							
October	355	31	$ 228.73	$ 15.12	$ 243.85	$ .043	$ .687
November	496	30	1.36	13.55	14.91	.027	.038
December	374	31	2.68	15.73	18.41	.042	.049
1930							
January	522	31	2.35	18.48	20.83	.035	.040
February	372	28	2.17	15.32	17.49	.041	.047
March	529	31	9.90	15.89	25.79	.030	.049
Totals	2,648		$ 247.19	$ 94.09	$ 341.28	$ .036	$ .129

counterbalanced condition was reduced to 4 per cent, with a corresponding reduction in average power input to 8.76 k. w., or 11.74 h. p. (Graphs 2, A and B).

Still further correction of counterbalancing (Graphs 3, A and B) with the Pitman type of counterbalance (6920 pounds) reduced the difference in time between up and down strokes to 1.2 per cent, with the down stroke slightly the slower. This further reduced the power input to an average of 6.48 k. w., or 8.68 h. p.

In the development and use of the devices described above the writer wishes to acknowledge the assistance of all members of the C. C. M. O. Co. Torrance electrical department, and in particular that of Mr. P. H. Mize, electrical foreman, and his principal assistant, Mr. J. O. Boyd. Without the hearty and complete co-operation of the two last-named, much greater difficulty would have been encountered in the handling of our problems.



Pump protector.

GRAPHIC SPEED VARIATION METER CURVE

TORRANCE No. 75 January 25, 1929

Type pump, Plunger, Size 2½" ... Sucker Rod, ¾" ... 1 Cycle=120 Divisions=3.30 Sec.=100%
Pumping Depth, 3200 ft. ... Size Tubing, 2½" ... Upstroke=67 Divisions=1.84 Sec.= 56%
Sec. per stroke, 3.30 ... Length Stroke 32" ... Downstroke=53 Divisi'ns=1.46 Sec.=44%
Barrels Fluid/24 hours, 80 ... Gravity 16.0 ... Rod Upstroke=12% Slower
Type Counterweight—Pony beam and concrete block.
Lbs. Counterweight, 1400.

GRAPHIC SPEED VARIATION METER CURVE

TORRANCE No. 75 January 26, 1929

Type pump, Plunger, Size 2½" ... Sucker Rod, ¾" ... 1 Cycle=100 Divisions=3.10 Sec.=100%
Pumping Depth, 3200 ft. ... Size Tubing, 2½" ... Upstroke=52 Divisions=1.61 Sec.=52%
Sec. per stroke, 3.10 ... Length Stroke 32" ... Downstroke=48 Divi'ns=1.49 Sec.=48%
Barrels Fluid/24 hours, 80 ... Gravity 16.0 ... Rod Upstroke=4% Slower
Type Counterweight—Pony beam and concrete block.
Lbs. Counterweight—700 added—Total 2100.

GRAPHIC SPEED VARIATION METER CURVE

TORRANCE No. 75 January 28, 1929

Type pump, Plunger, Size 2½" ... Sucker Rod, ¾" ... 1 Cycle=113 Divisions=3.40 Sec.=100%
Pumping Depth, 3200 ft. ... Size Tubing, 2½" ... Upstroke= 56 Divis'ns=1.68 Sec.=49.4%
Sec. per stroke, 3.40 ... Length Stroke 32" ... Downstroke= 57 Div's=1.72 Sec.=50.6%
Barrels Fluid/24 hours, 80 ... Gravity 16.0 ... Rod downstroke=1.2% Slower
Type Counterweight—Pitman. Lbs. Counterweight, 6,920.

Table 3

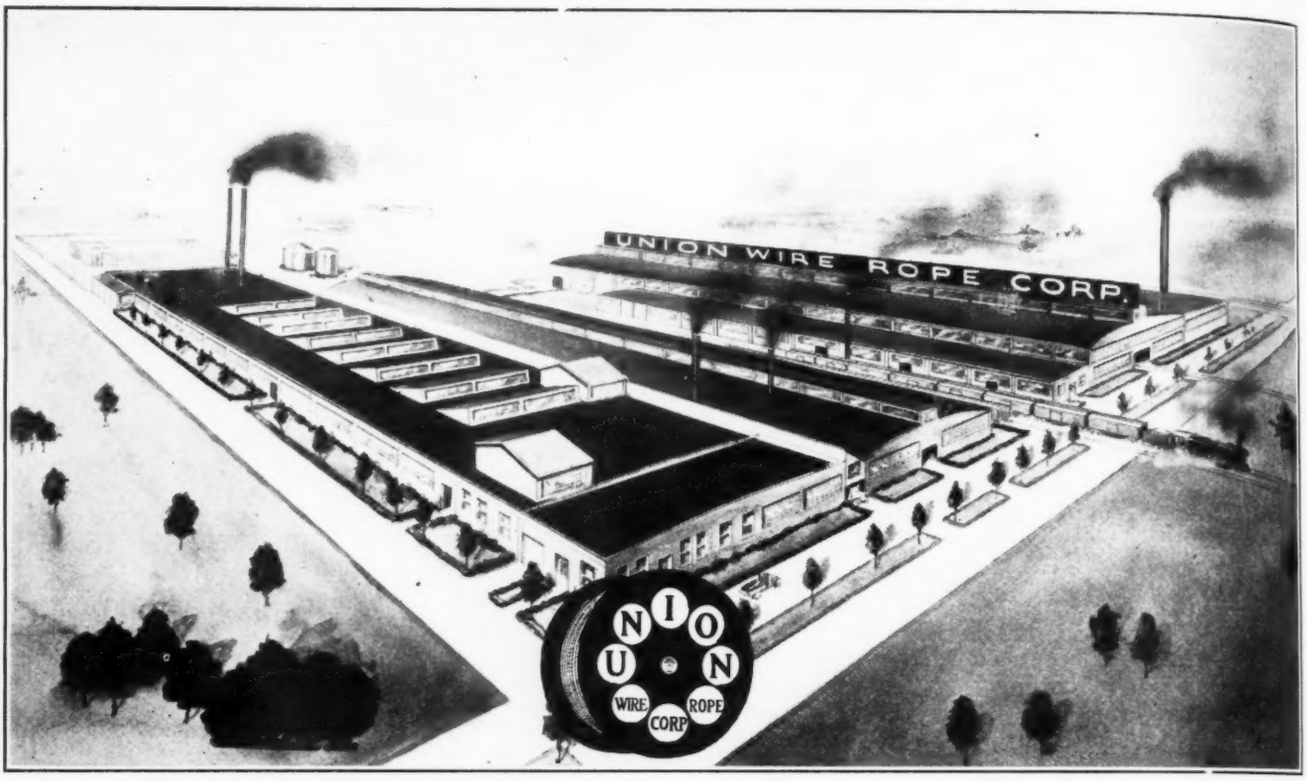
Comparison of Pumping Methods
Chanslor-Canfield Midway Oil Company
Well No. Torrance 76

Month and year	Net Prod.	Days Prod.	Labor Material Cost	Power Cost	Total Upkeep Cost	Lifting Cost Per Bbl. Power Only	Total Lifting Cost Per Bbl.
Pumping 30-tooth sprocket 19¾ strokes per minute							
1929							
April	733	30	$ 15.09	$ 35.86	$ 50.95	$ .049	$ .070
May	767	31	2.05	41.63	43.68	.054	.057
June†	342	14	1.66	16.17	17.83	.047	.052
July	616	31	7.02	38.55	45.57	.063	.074
August	614	31	3.41	35.79	39.20	.058	.064
September	416	30	228.85	59.22	288.07	.142	.692
Totals	3,488		$ 258.08	$ 227.22	$ 485.30	$ .065	$ .139
Pumping 9-tooth sprocket, 7 strokes per minute							
1929							
October	704	27	$ 208.20	$ 35.10	$ 243.30	$ .050	$ .346
November	662	30	1.36	17.76	19.12	.027	.029
December	635	31	83.54	17.90	101.44	.028	.160
1930							
January	678	31	26.82	16.07	42.89	.024	.063
February	651	28	12.61	14.81	27.42	.023	.042
March	676	31	1.58	17.17	18.75	.025	.028
Totals	4,006		$ 334.11	$ 118.81	$ 452.96	$ .030	$ .113

†June—off production 15 days, account curtailment.

» » » » OIL FIELD

Designed and Built to Meet



6x7 CONSTRUCTION

This construction is termed 6x7. It is composed of 6 strands and has 7 wires in each strand, therefore its name, 6x7.

This construction is generally used as a cable tool drilling line where a Manila Cracker is required. When used with a Cracker the lay of the rope is always left lay, owing to the fact that a Manila Cracker is always left lay.

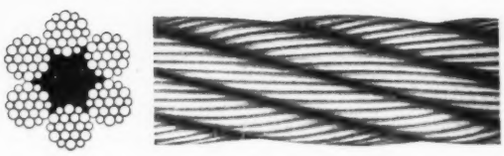
It is also used as a Sand Line or Bailing Line, even though many rotary operators use 6x19 for Bailing Lines. Right lay is almost universally specified for either Sand or Bailing Lines.

This construction is also used for Pumping Lines and Pull Lines. It has other uses, but these are the major services which this construction is called upon to perform in the oil country.

6x7 CONSTRUCTION

Rope Diam. Inches	Approx. Weight Per Foot, Lbs.	CAST STEEL List Price	CAST STEEL Strength, Tons	MILD PLOW STEEL List Price	MILD PLOW STEEL Strength, Tons	PLOW STEEL List Price	PLOW STEEL Strength, Tons	IMPROVED PLOW STEEL List Price	IMPROVED PLOW STEEL Strength, Tons
1/4	.094	.04	2.	.05	2.15	.06	2.35	.07	2.7
5/16	.12	.04 1/4	2.52	.05 1/4	2.72	.06 1/4	2.95	.07 1/4	3.4
3/8	.15	.04 1/2	3.1	.05 1/2	3.35	.06 1/2	3.65	.08 1/4	4.2
7/16	.21	.05 3/4	4.3	.06 3/4	4.7	.08	5.15	.08 3/4	5.9
1/2	.29	.07	5.8	.08 1/2	6.3	.10 1/2	6.9	.11 1/2	7.9
9/16	.38	.09	7.5	.10 1/2	8.2	.12 1/2	9.	.13 1/2	10.3
5/8	.48	.11 1/2	9.4	.13 3/4	10.3	.16 1/4	11.3	.17	13.
7/8	.59	.13 1/2	11.5	.16	12.6	.19	13.8	.20 1/2	16.
3/4	.84	.18 1/2	16.5	.22	18.1	.26	19.8	.28 1/2	22.8
7/8	1.15	.23	22.4	.27	24.6	.32 1/2	26.8	.37	30.8
1	1.50	.29	29.	.35	31.9	.41	34.8	.48	40.
1 1/8	1.90	.36	36.4	.44	40.	.51	43.6	.58	50.

6x19 CONSTRUCTION



6x19 CONSTRUCTION

Rope Diam. Inches	Approx. Weight Per Foot, Lbs.	CAST STEEL List Price	CAST STEEL Strength Tons	MILD PLOW STEEL List Price	MILD PLOW STEEL Strength, Tons	PLOW STEEL List Price	PLOW STEEL Strength, Tons	IMPROVED PLOW STEEL List Price	IMPROVED PLOW STEEL Strength, Tons
1/4	.10	.09	2.1	.10 1/2	2.3	.12	2.5	.13	2.9
5/16	.16	.09 1/4	3.2	.10 3/4	3.5	.12 1/2	3.9	.13 1/2	4.5
3/8	.23	.09 1/2	4.5	.11	5.	.13	5.5	.14 1/2	6.3
7/16	.31	.10 1/2	6.	.12	6.6	.14	7.3	.15 1/2	8.4
1/2	.40	.12	7.7	.13 3/4	8.5	.16	9.4	.17	10.8
9/16	.51	.13 3/4	9.6	.15 3/4	10.6	.18 1/4	11.7	.19	13.5
5/8	.63	.15 3/4	11.8	.18	13.1	.21	14.4	.22 1/2	16.6
3/4	.90	.20 1/2	16.8	.24	18.7	.28	20.6	.31	23.7
7/8	1.23	.25	22.8	.29	25.4	.34 1/2	28.	.39	32.2
1	1.60	.31	29.5	.37	33.	.43	36.5	.50	42.
1 1/8	2.03	.38	37.	.46	41.5	.54	46.	.62	53.
1 1/4	2.50	.46	46.	.56	51.	.65	56.5	.75	65.
1 3/8	3.03	.56	55.	.68	61.5	.79	68.	.90	78.5
1 1/2	3.60	.66	65.	.80	72.5	.93	80.5	1.10	92.5
1 5/8	4.23	.77	76.	.94	85.	1.08	94.	1.30	106.
1 3/4	4.90	.90	88.	1.10	98.	1.30	108.	1.60	124.
1 7/8	5.63	1.02	100.	1.25	112.	1.46	123.	1.75	142.
2	6.40	1.16	114.	1.34	127.	1.58	140.	1.85	161.
2 1/4	8.10	1.44	141.	1.70	160.	2.00	176.	2.50	202.
2 1/2	10.	1.75	176.	2.10	195.	2.50	214.	2.80	246.

UNION WIRE LINES

When writing UNION WIRE ROPE CORP. *please mention The Petroleum Engineer*

WIRE LINES « « « «

Oil Country Requirements

Union Oil Industry Wire Lines are built by oil men. The executives of the Union Wire Rope Corporation are all men of long practical experience in the petroleum industry. Union engineers have studied wire lines for years in actual service in the oil fields and know the conditions to be met. Union Wire Lines for every purpose in the oil industry have been perfected to meet the unusual conditions under which wire lines are used in the field, and to perform with the highest possible degree of satisfaction in this gruelling service.

Remarkably uniform high quality is possible in Union Wire Lines because they are produced completely in the Union factory—from drawing and tempering the wire to fabricating the finished rope.

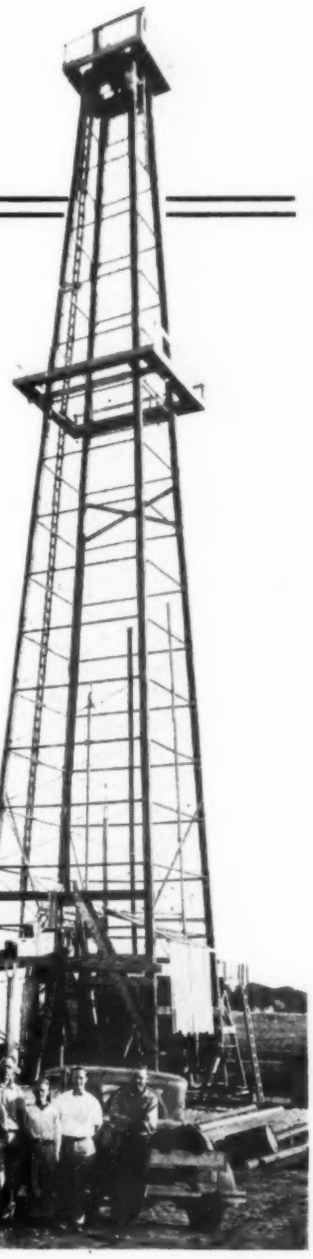
UNION WIRE ROPE CORPORATION

3 North Madison Avenue, Tulsa, Okla.

Factory: 21st and Manchester, Kansas City, Mo.

Oil Country Sales Offices:
338 Kennedy Building
Tulsa, Okla.

Oil Country Distributors:
JARECKI MFG. COMPANY
Stocks at Branch Stores



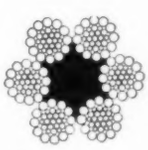
6x19 Construction—Continued

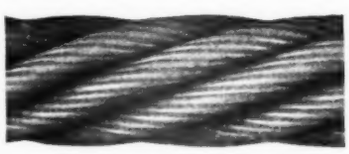
This construction is termed 6x19. It derives its name from the number of strands required to make up the rope and the number of wires which are required to make up the strand. This construction has 6 strands and 19 wires in each strand, therefore its name, 6x19. This construction has a heart or core which is either hemp or wire. Hemp or wire center is designated by the customer unless we are called upon to make a recommendation. Hemp or wire center is dependent upon the nature of the service which the rope is expected to perform.

This construction, or types of 6x19 construction, is used for cable tool drilling lines (when used direct without a Manila Cracker), cleaning out lines and swabbing lines. In all such service hemp center is required. The lay or direction which the strands are twisted in making this rope may be either right or left lay, as designated by the customer.

The grade of steel may either be Cast Steel or Mild Plow. We recommend Mild Plow, owing to its greater strength and resistance to abrasion than that of Cast Steel, which usually results in the consumer receiving longer service compared to the price per foot of that of Cast Steel.

6x31 CONSTRUCTION





This construction is termed 6x31. It is composed of 6 strands and has 31 wires in each strand, therefore is named 6x31.

This construction is used for Tubing and Sucker-Rod Lines. It is used for services where sheaves and drums are small, or the operation requires a rope that is adaptable to reverse bends.

The grade of steel usually is specified as Plow Steel or Improved Plow Steel—preferably Improved Plow Steel. It is somewhat easier to handle and less likely to kink. The lay of the rope is either right or left lay, as specified by the customer.

Information on other constructions that are not listed in this article, prices, engineering information as to their adaptability for the work required of them, will be furnished upon request.

6x31 CONSTRUCTION

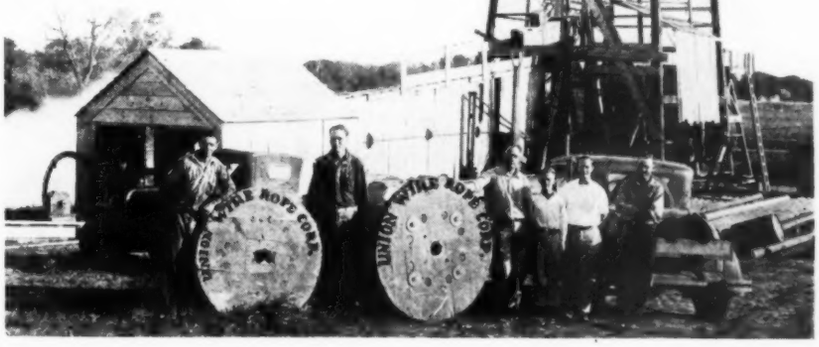
Rope Diameter, Inches	Approx. Weight Per Foot, Lbs.	PLOW STEEL		IMPROVED PLOW STEEL	
		List Price	Strength, Tons	List Price	Strength Tons
1/2	.39	.19	9.2	.20	10.6
9/16	.49	.22 1/2	11.5	.23	13.2
5/8	.61	.25	14.	.27	16.1
3/4	.87	.34	19.8	.36	22.8
7/8	1.19	.43	26.5	.46	30.5
1	1.55	.52 1/2	34.4	.59	39.5

UNION SPECIAL ROTARY WIRE LINES

After extensive study and experiments, the technical staff of Union Wire Rope Corporation, with the assistance of practical field men, have perfected a wire rope for rotary drilling. This rotary line has been in use for two years and has been found satisfactory.

It is made from the highest quality wire (Improved Plow Steel).

This line was designed with a special construction so it imparts to the rope flexibility, strength, and resistance to crushing.



UNION WIRE LINES

When writing UNION WIRE ROPE CORP. *please mention The Petroleum Engineer*

Treated Water *for* Refinery Use

By **Maxcine J. Japour,** ***Chief Chemist, Champlin Refining Co.***

THE question of water supply is a vital one in oil refining. Soft, fresh water is necessary for use in boilers and for treating oils. It is also highly desirable for use on cooling coils in condenser boxes and other places where scale accumulates to such an extent that the efficiency of the cold water is materially reduced. In this section of the Mid-Continent fields the water situation is serious and the question of procuring suitable water is an economic necessity.

The water used by the Champlin refinery is obtained from wells drilled by the company, this being the only available source of fresh water. The analysis on this water is as follows:

Carbonic acid	0.58	Grains/gal.	
Calcium carbonate	11.4	"	"
Magnesium carbonate	1.7	"	"
Sodium carbonate	0.81	"	"
Sodium chloride	5.08	"	"
Sodium sulfate	2.1	"	"
Iron and Al. Oxide	0.7	"	"
Silica dioxide	0.7	"	"
Total	23.07	"	"

The precipitation of the calcium and magnesium carbonates on the hot condenser and ammonia tubes caused the formation of scale with a deposit of sometimes over an inch thick. This thick deposit insulated these pipes, causing the use of larger amounts of cold water and in the case of the ammonia coils necessitated the use of additional ammonia. It was found that if this scale was eliminated, many advantages would result; namely,

1. Less cold water would be required.
2. Less ammonia would be required.
3. The labor of removing this coating, or scale, and cleaning clogged pipes is eliminated.
4. Elimination of pump trouble due to clogging.
5. Elimination of corrosion.
6. Saving of volatile products due to better cooling.
7. A higher quality lubricating oil is obtained, due to lower refrigeration temperature.

The question of removing this scale was finally decided upon. The method of precipitating the calcium and magnesium salt by the lime-soda cold method was considered, but due to the large amount of water needed and due to the slowness of this process, this idea was abandoned. The zeolite, or base exchange, water softening method was next considered. By use of this method there is no delay, no heating of the water and zero hard water was obtained.

The cost of treating an entire refinery water supply was an expensive affair and to be a pioneer in this idea demanded no little amount of courage.

The zeolite method of softening water was used by laundries and for domestic purposes and for partial treatment since 1906. The base exchange properties were discovered by J. Thomas Ways in 1850 in his experiments with fertilizers. Gans, in 1906, in his German patent No. 197,111 made it applicable for industrial water softeners.

A great variety of zeolites have been used for water softening purposes. Zeolites are compositions containing various proportions of silica, aluminum, sodium, and frequently small amounts of calcium, magnesium, and iron. Some zeolites are artificially or synthetically prepared and some are obtained by treatment of natural mineral.

The reaction in the softening by the zeolite method may be designated by symbols as follows:

Zeolite as Z, then,

$$2\ NaZ + CaCo_3 \text{———} Na_2Co_3 + CaZ2$$

and

$$CaZ_2 + 2\ NaCl \text{———} CaCl_2 + 2\ NaZ$$

The same would be true for magnesium carbonate or the bicarbonates of these two salts.

The cost of this method of treatment is one-sixth of one per cent per thousand grains of hardness for each thousand gallons treated. The labor cost is about one-half of a man's wages per shift.

The refinery has been treating about a million gallons of water a day for approximately two years and the results have been entirely satisfactory. The analysis of the water after treatment is as follows:

Sodium carbonate	16.5
Sodium chloride	6.0
Silica dioxide	0.75
Iron and Al. oxides	0.35
Sodium sulfate	2.9
Calcium carbonate	0.15
Total	26.65

This water is used over the entire plant, going first to the refrigeration plant, then to the Diesel engines, and the condenser boxes; from there to the boilers and various other parts of the plant as shown in the accompanying chart.

Millions of gallons of water held in the spray pond for general refinery uses have been made soft by the excess amount of sodium carbonate that enters from the zeolite treated water. This water, like the zeolite treated water is being used in numerous places and the results are that everything around the refinery is free of all scale-forming substances and corrosion.

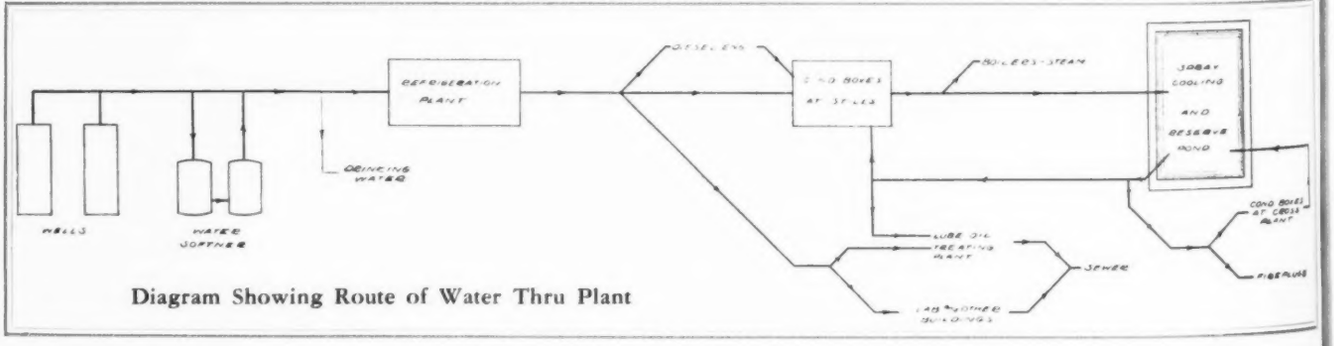


Diagram Showing Route of Water Thru Plant

Chemicals Used in

Processing High Sulfur Crudes

By C. B. FAUGHT,
Supt. Richardson Refining Co.

THE prominence of sour crudes produced in West Texas is enhanced by the large present production and the future potential production. Much of this oil is being transported to refineries in various parts of the United States. In the past it has been blended with sweeter crudes and processed in such small ratios that the refiners have not been greatly troubled with the special problems that arise in those plants where these crudes are processed straight.

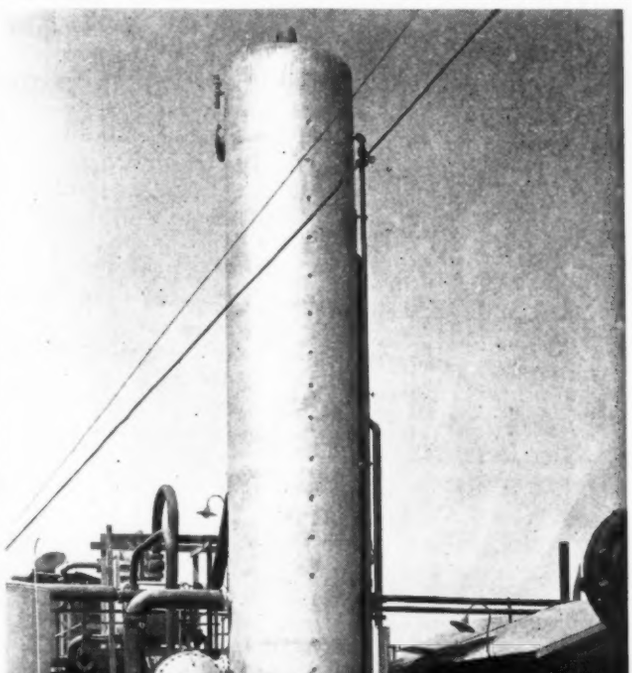
As production in West Texas increases, this ratio is being increased until the effect of the sour crude is being felt more and more.

The experience of the refiners of the straight sour crudes has an important place in the economic structure of the industry. It will be largely from these refineries that methods of manufacture and protection against corrosion will be solved.

This article will deal only with one phase, the processing of gasoline from crudes produced in Howard County, Texas, from the Roberts-Settles, Chalk and Henshaw pools. This crude is admittedly difficult to refine, due to its high sulfur content and the presence of fairly large quantities of magnesium and sodium chlorides.

Some West Texas sour crudes have an excellent lube cut, which is readily processed under vacuum, but the majority of these crudes are being run for gasoline and naphthas.

In dealing with the chemicals used in combating the action of the salts and the hydrogen sulfide, it must be remembered that the objective is cleaning the crude and rendering it as nearly sweet as possible.



Absorber at Natural Gasoline plant.

This processing is costly where standard specifications on the products are met. However, the gasoline produced from these crudes, when properly refined, is of an excellent quality, very high in anti-knock value, which brings a premium.

In the crude distillation, neutralization of the salts is of primary importance. Unless these salts are carefully neutralized several difficulties are encountered.

In the first place, when processing without a neutralizer the salts drop out as soon as the crude is heated and the salts hit an obstruction. The common use of heat exchangers for the preheating is granted. Usually heat exchange is available to raise the temperature of the crude to 300 to 400 degrees F. At these temperatures the salt will be deposited in the exchangers. Once the depositing is started it proceeds rapidly until in a very short time the system is plugged up. This requires a matter of hours. Salt carried into the tubes forms a flint-like deposit which is very hard to remove. It appears that all of the corrosion in the tubes, return bends and transfer line is due to salt. This action is rapid and constitutes a constant fire hazard.

On the other hand, where the salts are neutralized these troubles are greatly reduced. Some refiners settle the salt out of the crude before processing, but quantities of the chlorides do not settle and it is therefore necessary to take precautions.

Possibly the cheapest and most widely used neutralizer is chemical hydrate of lime. The most satisfactory method mixing and adding to the crude is to run a portion of one of the side streams from the tower into a mixing tank and add the lime to this portion, then inject this mix into the charging stock in definite quantities. Gas oil is a very satisfactory stock for this purpose as it contains no light ends and readily holds lime in suspension.

The quality of the lime that is used in the crude still differs from that used in cracking. A lime that has above 90 per cent calcium hydrate, $Ca(OH)_2$, and a mesh of 300, and which has a very slow settling rate is ideal, for the reasons that the high calcium hydrate content gives maximum neutralizing value, the extreme fineness assures maximum exposure to the chlorides and therefore quick reaction, and the slow settling rate prevents settling out during the passage through the still. On the settling test, this lime should show not more than 5 c. c. of clear oil above the mixture at the end of 24 hours.

The addition of this lime must be constant hour after hour and to assure this, a record should be kept of the amount used every hour and kept on the still report. Periodical additions of lime will not give satisfactory results. In the case of the crude under discussion 0.25 pounds per barrel is the minimum that can be used without trouble. Increas-

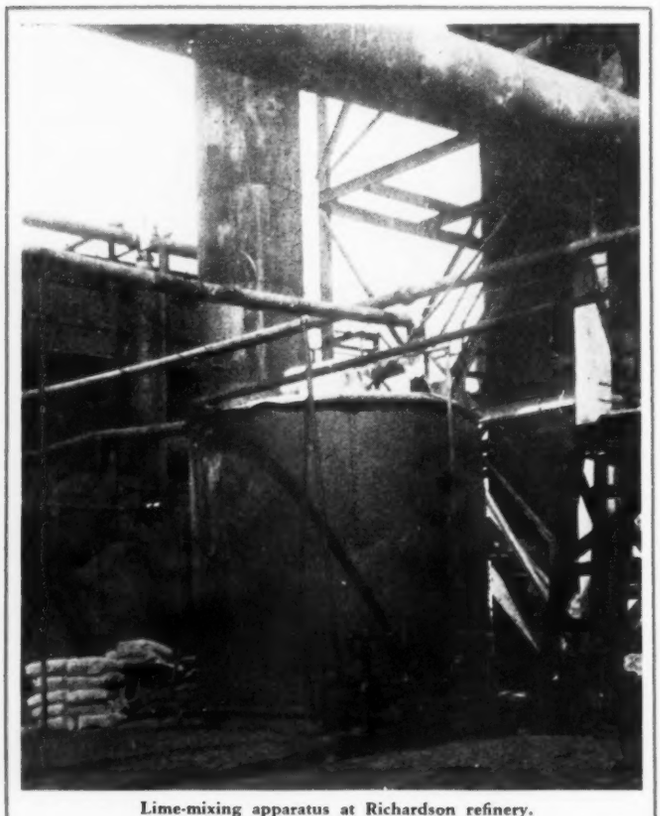
ing this amount does not improve conditions.

There is no deleterious effect on the gasoline from the use of lime. In addition to neutralizing the salts, there is some known action on the hydrogen sulfide. This fact is proven as a saturated solution of lime water will entirely neutralize hydrogen sulfide in gasoline. The lime keeps soft any coke formed, the addition of the correct quantity does not show in the B. S. & W. content of the fuel. On the other hand, it lowers this test. The B. S. & W. of the fuel from this crude when running down to heavy fuel of 8 Be. shows less than 0.1 per cent despite the large amount of salts present.

The life of the equipment is materially lengthened when these precautions are taken. After thirteen months of continuous operation of a pipe still, reducing to asphalt on a single flash system, none of the tubes, return bends nor the transfer line have been renewed. Very little corrosion is observed in the bubbling tower.

The removal of hydrogen sulfide from the overhead gasoline stream is very simple. This gas vaporizes readily and practically all of that amount found in the crude distills off in the top stream. Several neutralizers are in use, including anhydrous ammonia, lime water, soda ash solution, caustic soda solution and cold water. If allowed to remain in the distillates during the time that the temperature is being reduced from 300 degrees F. to normal, the hydrogen sulfide gas will be reabsorbed in the distillate. This will constitute a menace to the health and safety of the men and will eat up any equipment that it comes in contact with.

Of the solutions enumerated, the most effective is 18 Be. caustic solution. The reaction is principally sodium sulfide, which when dry is an extremely hard substance, which melts under heat between 600 and 800 degrees F., depending on its purity. A strong solution of caustic will not contain enough moisture to prevent the formation of this dry product which will deposit in the condensing equipment and will soon plug up the system. This deposit once formed is difficult to remove and may result in total loss of the part on the equipment in which the deposit is made. Danger begins when a caustic solution above 26 Be. is used.



Lime-mixing apparatus at Richardson refinery.

Agitators for treating gasoline.

When steam is used in the distillation process, alkali solutions are not practical as the steam weakens them too rapidly. When distilling dry in a pipe still as when topping or stripping only a fraction of the distillates, caustic solution works perfectly. An 18 Be. solution will gradually decrease in strength due to the withdrawal of the caustic from the solution in the reaction forming sodium sulfide, until the strength is 7 to 8 Be. At this point the solution should be taken out of the system as it is practically spent. The spending is gradual, and extends over a period of four to eight hours, depending on the amount of hydrogen sulfide in the distillate and the quantity of solution being circulated.

In the distilling unit in which steam is used, such as in the manufacture of lubricating oil distillates or asphalt, the use of cold water is most satisfactory. Water at 65 to 70 degrees F. will absorb large quantities of hydrogen sulfide. Water can be recirculated in the system until it absorbs its maximum and then dumped. This water can be discarded entirely or aeriated and used over again. However, water will not remove all of the hydrogen sulfide and a subsequent wash of alkali before treating will be necessary. Water is economical and cuts chemical costs materially. It will reduce the concentration of the hydrogen sulfide in the distillates to such a point that the danger to workmen is removed and the corrosion of equipment is slight.

Lime used in cracking stills is of a different nature from that used in crude stills. This lime should have a high neutralizing value and should settle rapidly. Larger quantities per barrel of charge are necessary and for that reason will increase the B. S. & W. content of the fuel unless the lime settles rapidly. In some still operations it has been determined that a lime containing 95 per cent calcium hydrate and has a settling rate of 50 c. c. is ideal. In cracking, certain of the higher sulfur compounds are broken down under temperatures above 500 degrees F. with the formation of hydrogen sulfide. The action of this compound is evidently much more rapid and violent than the natural hydrogen sulfide found in the crude, when at high temperatures. The high hydrate content gives rapid neutralization, but will not entirely eliminate corrosion. The lime keeps the coke soft and in this state it will wash out with the fuel, leaving the tubes and drums clean.

Economies Gained by

Centrifuging Diesel Engine Oil

By J. H. DAMERON

CENTRIFUGING Diesel engine fuel by pipe line companies to overcome inefficient engine operation when the cause is traced to the use of dirty fuel is a relatively recent practice. When this cause of engine inefficiency was observed, former methods were to heat the fuel, thereby settling out as much water and dirt as was possible. In centrifuging fuel oil, heat also is used to aid the process because the foreign matter in suspension is more readily thrown out by centrifugal force when oil is raised to a higher temperature. Centrifugal machines rotate the bowl several thousand r.p.m. generating a centrifugal force many thousand times the force of gravity. The practice of centrifuging fuel oil at pipe line stations was first used about three years ago, although this method of cleaning oil engine fuel has been used for some time on marine Diesels.

After the early test runs proved the value of this system installations became widespread. Some companies today have standardized on this method of cleaning fuel at each station on some of their lines.

At stations where excessive liner and ring wear, frequent spray valve, fuel pump trouble and irregular engine firing has been traced to dirty fuel, centrifuging has been found the most economical and rapid method of reducing operation and maintenance costs. The improvement in engine performance has been readily observed, shut-down time is less frequent, liner wear is not so great and loss of efficiency, because of the loss of power, also has been lowered.

At some stations it is not considered economical to add this auxiliary equipment, and the fuel problem is usually handled by heating the fuel to a temperature of 110 to 130 degrees to accelerate the settling out of a part of the water and heavy foreign matter, such as scale and sand. Two cone-bottom tanks are usually required for this, one in which to heat the oil and settle it, while the other is used as a working fuel tank. After the oil has settled 24 or more hours the water and abrasive material is drawn off through a drain cock in the bottom of the tank.

On some installations the oil is raised to a temperature higher than 130 degrees and agitated to drive off some of the gas in the oil should it happen to be hydrogen sulphide gas. The flow lines to the engine from the tanks are placed several inches above the tank bottom so that a cleaner fuel will be drawn out. With a centrifuge plant this process is greatly accelerated and a fuel free from water and abrasive material is obtained. In addition to having a cleaner fuel, the gravity is raised to some extent and the section of the station grounds where the fuel is cleaned is usually in a neater condition.

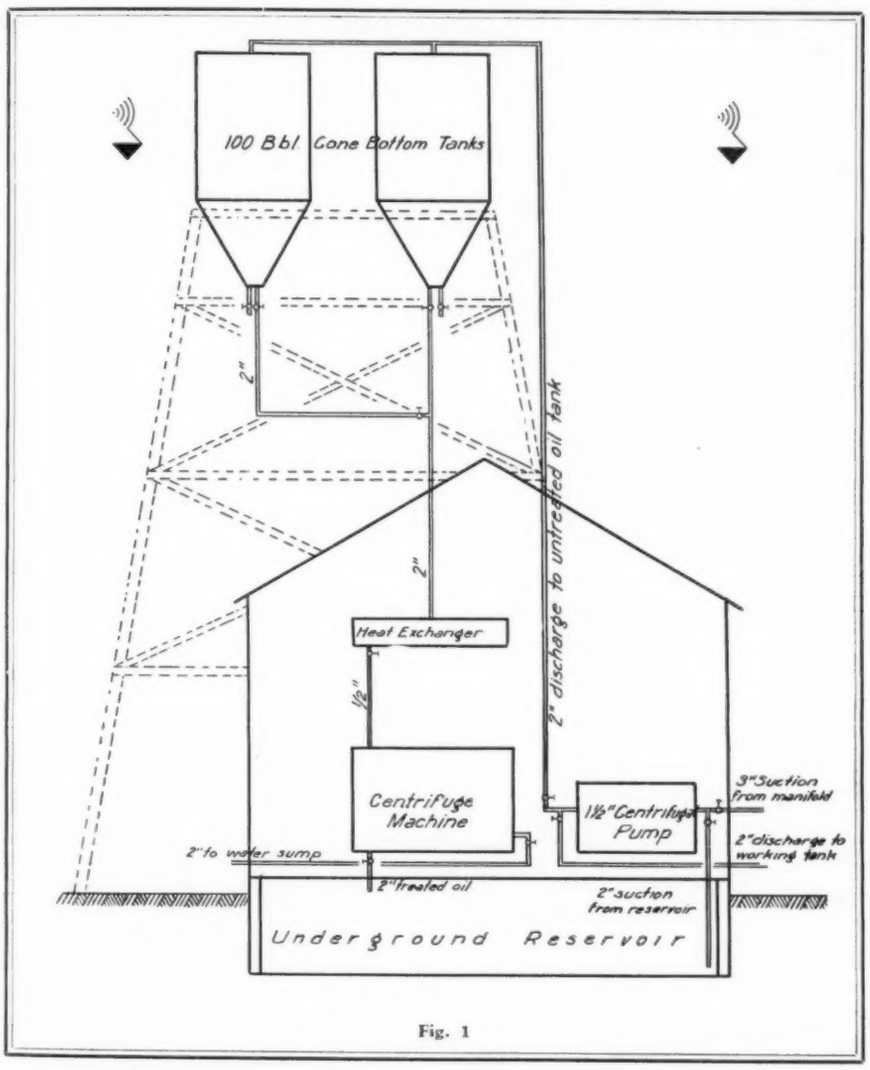


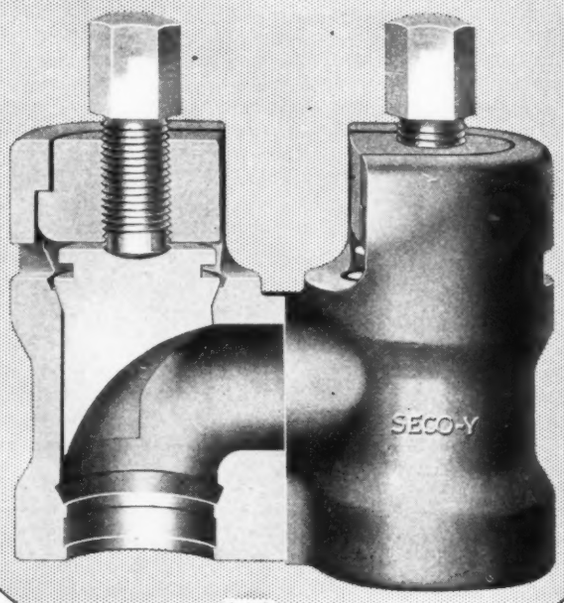
Fig. 1

Layouts for centrifuging machines vary widely in detail throughout the Mid-Continent, but in the main their operation is identical. The difference in layouts is usually because each has been designed to meet local conditions as far as heating lines are concerned. Ordinarily a machine with a capacity sufficient to handle about 30 per cent more fuel oil than the rate of oil consumption by the engine is selected. This gives a good margin of reserve to permit cleaning of the machine or making adjustments and also allows for building up a reserve of cleaned fuel oil.

The unit, along with transfer pumps, spare equipment and accessories, are housed in an inexpensive building just large enough to permit free movement of operators. For most plants a building 12 by 12 feet or a little smaller is

SECO RETURN BENDS

FURNISHED IN A VARIETY OF DESIGNS



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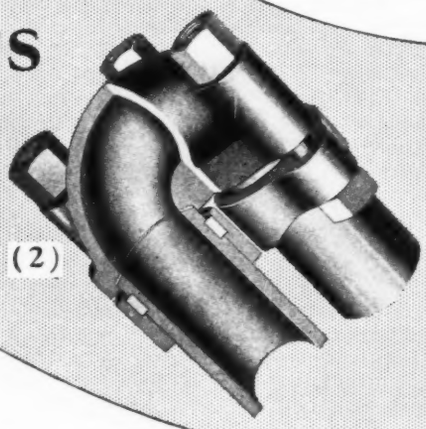

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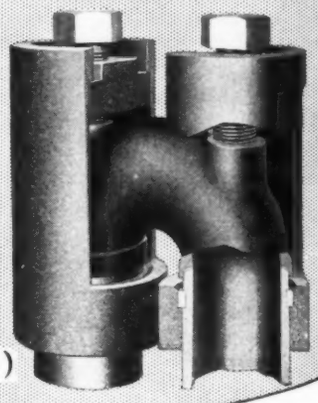

(3)

SUPPLEMENTING the general purpose, bolted-on type A Seco Return Bend, Types A-1 and Y are offered especially for cracking still duty.

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large enough. Some have concrete floors and all of the centrifuging machines are mounted on a concrete base, usually 18 inches deep and flush with the floor. Some are mounted on a concrete pedestal 6 to 12 inches above the floor level, but this makes it less convenient to remove the bowl or work on top of the machine.

As far as possible it is station practice to have one or two members of the crew operate the machine. Where the operation of the separator has been mastered thoroughly, little attention other than starting and stopping is required. The operator is a member of the crew on tour and attends to the lubrication when the machine is started for a day's run.

The newer installations of centrifuging machines are being equipped with a solenoid valve which is operated by two magnetized poles. This valve automatically closes the valve on the dirty oil supply line to the machine in case the motor stops at any time while oil is being cleaned. Thus the possibility of the machine and building being flooded with oil as a result of the machine stopping because of power or motor failure is eliminated.

At the present time particular attention is being given to centrifuging fuel oil in West Texas. At oil engine stations in that section of the country virtually all of the engines are fueled with the hydrogen sulphide crude produced locally. The use of this crude as engine fuel has caused many evils, including excessive liner wear, spray valve and fuel pump trouble, fuel line corrosion and contamination of crank case oil.

Excessive liner wear in Diesel engines was one of the most surprising and costly troubles traced to the use of sulphur-contaminated oil as a fuel. In some instances it was necessary to replace liners aiter about one year's service. In the early stages of pumping in that region, a group of engines showed an average run of 232 hours per .001 inch liner wear. Changes in numerous operation features, principally heating and settling the fuel oil, improved conditions perceptibly.

At a station where the use of sulphur crude as a fuel has been a practice for several years a centrifuging machine has recently been installed. Close check of liner wear has always been kept at this station. It will be several months before the record of improvement in engine performance will be recorded, but a distinct improvement in engine performance has been noted during the two months that the fuel has been centrifuged.

Analysis of the oil before and after being cleaned revealed that all water and abrasive material was being removed. Engineers conducting the tests and intimately familiar with the problem are of the opinion that the removal of the water will overcome a great many troubles. The sulphur in an oil such as West Texas crude burns to sulphur dioxide and sulphur trioxide. If any water be present, these will react and form sulphurous or sulphuric acid and cause pitting on the metal.

Centrifuging does not remove the sulphur content of the West Texas crude oil, but it does remove the hydrogen sulphide gas which is in solution with the oil. With the removal of water, gas and abrasive matter, less pitting is anticipated and liner wear is expected to be reduced. Less trouble is also expected from valves, fuel pump, crank case oil and fuel lines. It was noted that as soon as the fuel lines were loaded with clean fuel the engines started operating more smoothly and the order of firing was more regular.

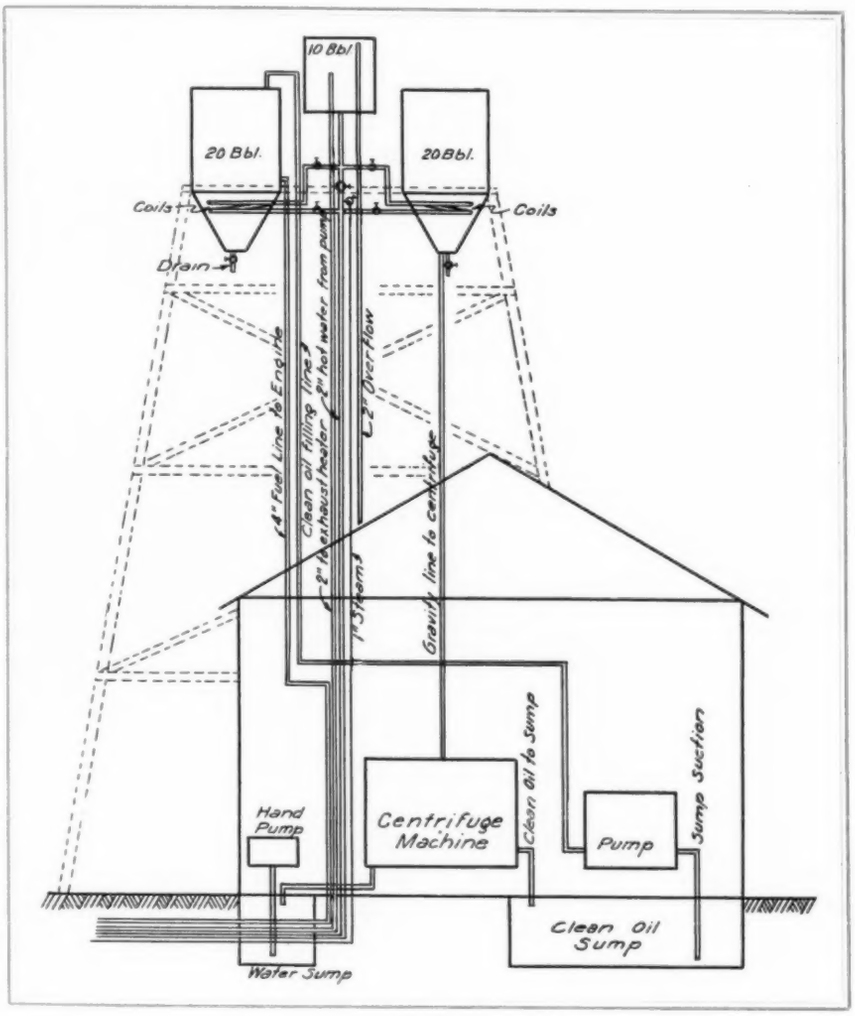


Fig. 2

Tests of the West Texas crude used as fuel showed it to contain anywhere from one and one-half to three per cent hydrogen sulphide gas. The water in the oil was not unusual in quantity, but was believed to be causing considerable trouble. The dirt removed consisted of tank scale, very common in West Texas because of rapid corrosion, sand and less abrasive matter. On an average of one-tenth of a pound is removed from each barrel of fuel put through the machine.

The layout for the West Texas plant was somewhat more elaborate than installations in similar plants because of the hazard connected with handling hydrogen and sulphide gas. At first a pressure-tight machine was installed and the fumes and gas carried out of the building through a vent pipe.

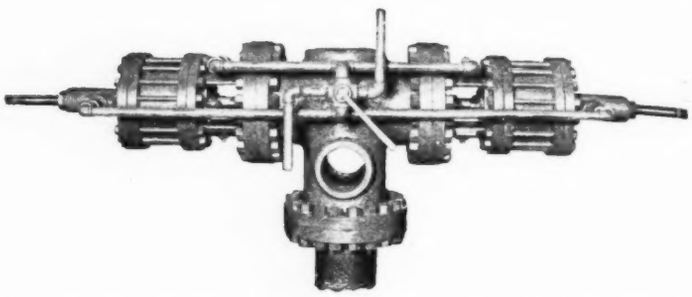
An open type machine was later installed. This necessarily called for a building with louvered walls to aid in preventing poison gas collecting in the building and presenting a safety hazard to the operator. A ventilator was put in the roof and, with the aid of the wind, so characteristic of West Texas, little trouble is experienced

C-I-W Manually Operated Blowout Preventer

The Manually Operated Preventer is identical in design and construction, with the exception of closing and mounting. This preventer is closed by wrenches extended 14 feet from each side of the preventer which close the rams around the pipe exactly as a valve is closed. Universal joints mounted on ram closing screws permit a wide latitude of closing positions.

The preventer is screwed directly onto the last string of casing. The rams, as well as those in the Steam Operated Preventer, are lubricated by Alemite connections.

C-I-W Steam Operated Blowout Preventer



On the Steam Operated Blowout Preventer the steel rams are closed by steam or other pressures by means of a 4-way operating valve which is located at a safe and easily accessible distance from the well. A quarter turn of the valve is all that is necessary to close or open the preventer.

Extension wrenches which securely lock the solid steel rams around the drill pipe are standard equipment. They are of sufficient length to assure safety to the operator in using them. Universal Joints and 48" diameter closing wheels are also furnished if desired.

The preventer is flanged to the last string of casing, below the derrick floor, completely out of the way of all drilling operations. The well may be brought in through flow line openings in each side of the preventer, located below the rams.

C-I-W Tubing Control Heads

C-I-W Tubing Control Heads are made in two types: The Heavy-Duty type, tested to 6000 lbs. per square inch, and the Regular type, tested to 1200 lbs. per square inch. Each is a complete unit in itself. No stuffing boxes, packing glands, tubing slips, extra equipment, etc., are necessary to handle any tubing job.

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Special ratchet lever jacks permit speed and instantaneous opening and closing of the rams. Simultaneous with this action the tubing is packed and unpacked. Ram screws are also provided to furnish additional safety when handling tubing. The rams are machined on top to support full strings of tubing by means of the couplings.

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The faces of the rams are accurately machined to exactly fit the various sizes of drill stem, tubing and casing. The rams are packed with a patented rubber packing that is so designed to pack tighter as the pressure increases. The drill stem casing or tubing is rigidly held between this circular steel vise and rubber packing, positively preventing the passage of gas, oil and pipe from the hole.

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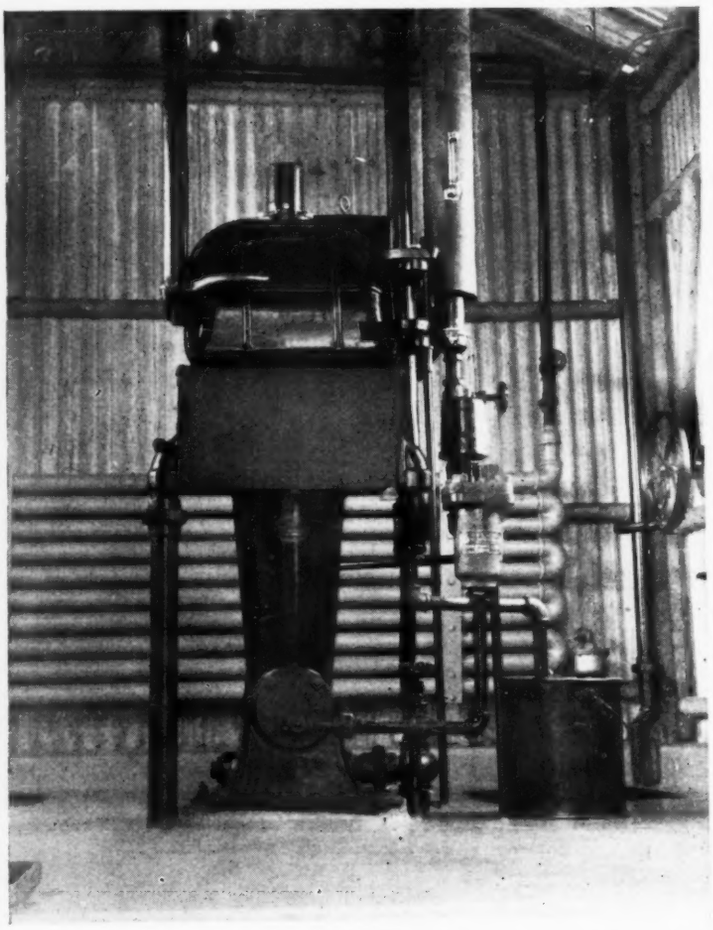


Closed type centrifuge with solenoid on flow line at right.

in freeing the building of gas.

The building is located a safe distance away from the station to reduce the fire hazard. Practice on this installation is to use two 100-barrel cone-bottom tanks. Fuel is delivered into one of these tanks by a one-and-one-half-inch centrifugal pump pulling a suction from the station manifold or main pump suction. The tank is high enough to give an eight-pound head on the gravity line to the machine.

The untreated oil passes through a heat exchanger in the building, which raises its temperature to 130 degrees, and then on to the centrifuge. Clean oil is discharged into a 50-barrel concrete sump tank. It is later picked up by the centrifugal pump in the building and delivered to the other 100-barrel overhead tank, which is usually used as a working tank.

In other areas where so many problems are not encountered and where water and dirt in the fuel cause most of the trouble, the closed type machine in a 12 by 12 building is used and the piping layout takes advantage of the existing steam or hot water lines.

A good example of taking advantage of the existing hot water lines for the installation of a centrifuge is found in the Prairie Pipe Line Co.'s Addington, Okla., station. This system is one by which the water is heated in an exhaust jacket and circulated by a centrifugal pump. The water circulates through the system to a 10-barrel tank located on the tank derrick along with other tanks. From there it gravitates back to the exhaust jacket, is reheated and picked up by the circulating pump. Two 20-barrel cone-bottom tanks equipped with coils are located by the side and under the water tank.

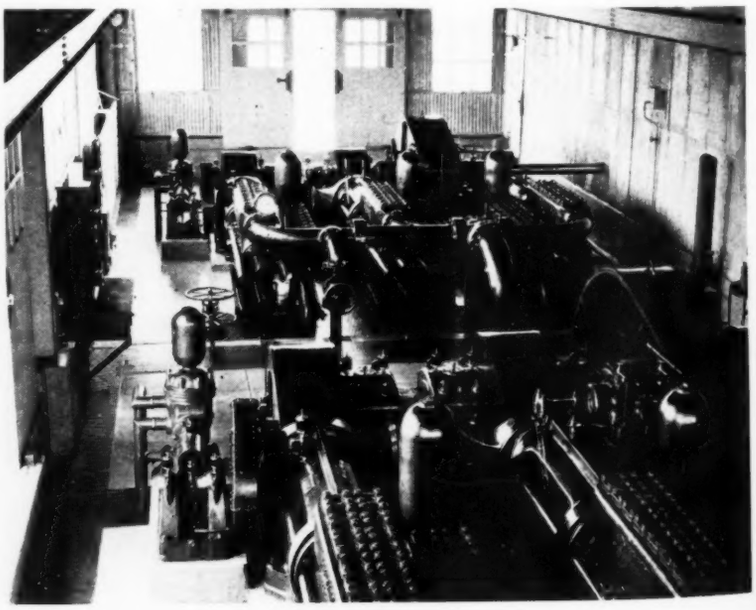
One of these is used as a fuel working tank and the other serves as a heating tank for the dirty oil going to the centrifuge. Dirty fuel is heated to 130 or 140 degrees in this tank and gravities to the machine. Clean oil is delivered into a clean oil sump and picked up by a small pump and delivered to the working tank. The water drains into a water sump and is later pumped out with a hand pump.

The valve arrangement permits either tank to be heated. In the event sufficient heat is not being transmitted during the winter months, a one-inch steam line has been tied into the system to permit raising the temperature of the water.

It is interesting to note that on virtually every installation where water and dirt in the fuel oil were found to be giving trouble, liner wear was reduced 50 or more per cent. At stations identical in equipment and operating at about the same load it was found that those equipped to centrifuge fuel oil had 50 per cent less liner wear than those not equipped with centrifuges. On one company's system the liner wear record has been consistently cut in half over a period of time following the installation of the fuel-cleaning auxiliary at stations.

On these same stations spray valve and fuel pump troubles have been corrected. On some of the engines a frequent cleaning and regrinding of the spray valves was necessary, and the fuel pump likewise was a source of trouble because of the dirt impairing the plungers. Now these former sources of trouble are checked only every 2,500 or 3,000 hours, and so far have been found in good condition, needing only slight working over.

At an isolated station in Oklahoma where two grades of oil — Panhandle and Mid-Continent — are handled by pumps driven by 400-horsepower vertical engines, erratic liner wear was observed the first 9,000 hours of operation. These units handled 1,065 barrels hourly against a line



Pump room side of Diesel-powered station.

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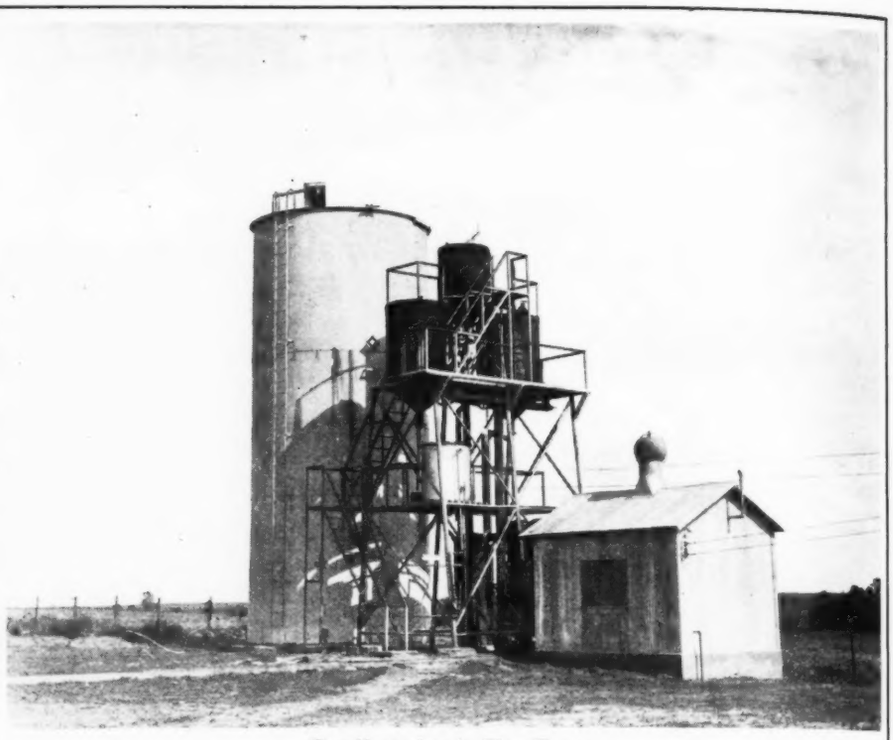
pressure of 710 pounds. The liner wear the first 4,000 hours was .005, while the average wear the next 2,000 hours was .00175 per 1,000 hours. Measurements taken after the next 3,000 hours running showed the average wear to be .004 per 1,000 hours and the average over the 9,000-hour run was .0039 per thousand hours. Some of the variation was due to the variation in temperature of the machinery and instruments when the measurements were taken.

During this time the spray valves were renewed every 500 hours and the exhaust and intake valves were ground every 1,000 hours. The fuel pumps likewise gave considerable trouble. During the first part of the run the station grounds were dusty and the soil had a sandy texture. Air filters were installed and ten or more pounds of dirt taken from these every 1,000 hours over a short period.



Centrifuge plant in West Texas.

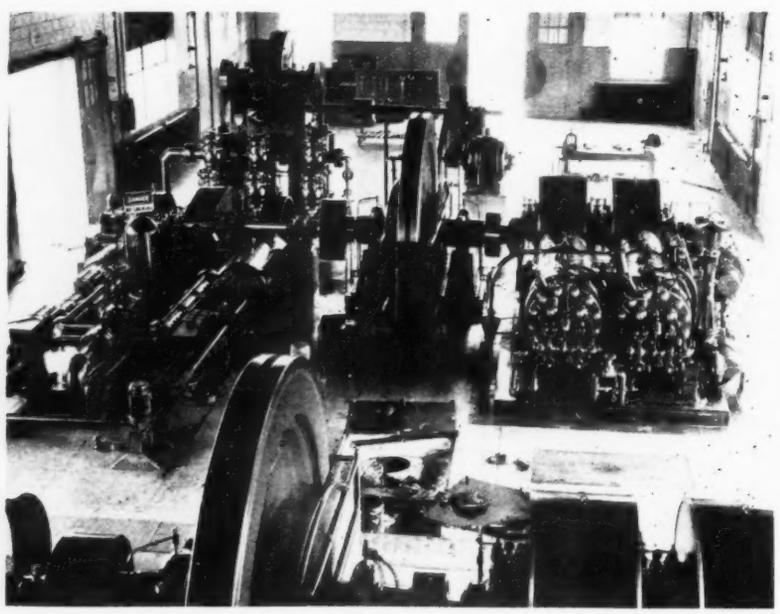
A centrifugal machine was installed and five pounds of dirt and twelve gallons of water were removed from the first 404 barrels of fuel treated. The dirt contained scale and sand, but for the most part a dark, sticky substance. The engines have run better than 1,000 hours since the installation of the centrifuging machine and no trouble had been experienced with spray valves or exhaust and intake valves.

The engine performance immediately showed an improvement and irregular firing ceased. This indicated that, although the water in the fuel may not cause trouble if uniformly distributed in the oil, it apparently had a tendency to agglomerate in coarse drops so the water was possibly concentrated in a small per cent of the oil volume. This would cause incomplete combustion and gumming of the rings and the liner.

At another station in the Mid-Continent, operation and maintenance costs were somewhat above the average. Units were performing in a manner similar to the conditions described above and the source of the trouble was traced to dirty fuel which was being purchased. Following the installation of a separator the cause of the trouble was removed and over a period of months the station's maintenance cost fell back to a figure considered average.

This station continues to use its auxiliary equipment and is removing about one pound of dirt from every six barrels of fuel run through the machine. The following tabulated report of cleaning fuel oil for the first 25 days of March at this station is fairly representative of reports from other sections of the country:

Date	Barrels of Oil Cleaned	Pounds of Dirt Removed
March 1, 1930	22.92	6
March 2, 1930	20.06	6
March 3, 1930	25.27	6
March 4, 1930	29.34	7
March 5, 1930	26.64	5
March 6, 1930	34.64	4.5
March 7, 1930	34.64	4.5
March 8, 1930	23.96	3.5
March 9, 1930	22.71	4
March 10, 1930	14.63	2.5
March 11, 1930	22.61	3
March 12, 1930	22.73	3
March 13, 1930	24.06	5
March 14, 1930	18.62	3.5
March 15, 1930	33.37	4
March 16, 1930	25.27	4
March 17, 1930	18.72	2.5
March 18, 1930	26.52	5
March 19, 1930	29.30	5
March 20, 1930	24.02	4.5
March 21, 1930	29.26	5
March 22, 1930	29.38	5.5
March 23, 1930	30.59	5
March 24, 1930	26.72	4
March 25, 1930	15.96	3
Totals:	632.04 Bbls.	111 Lbs.



Making repairs at an oil engine station in Texas.

New Heat Resisting Lubricants

By I. A. CLARK
Chemist, Mid-Continent Petroleum Corporation

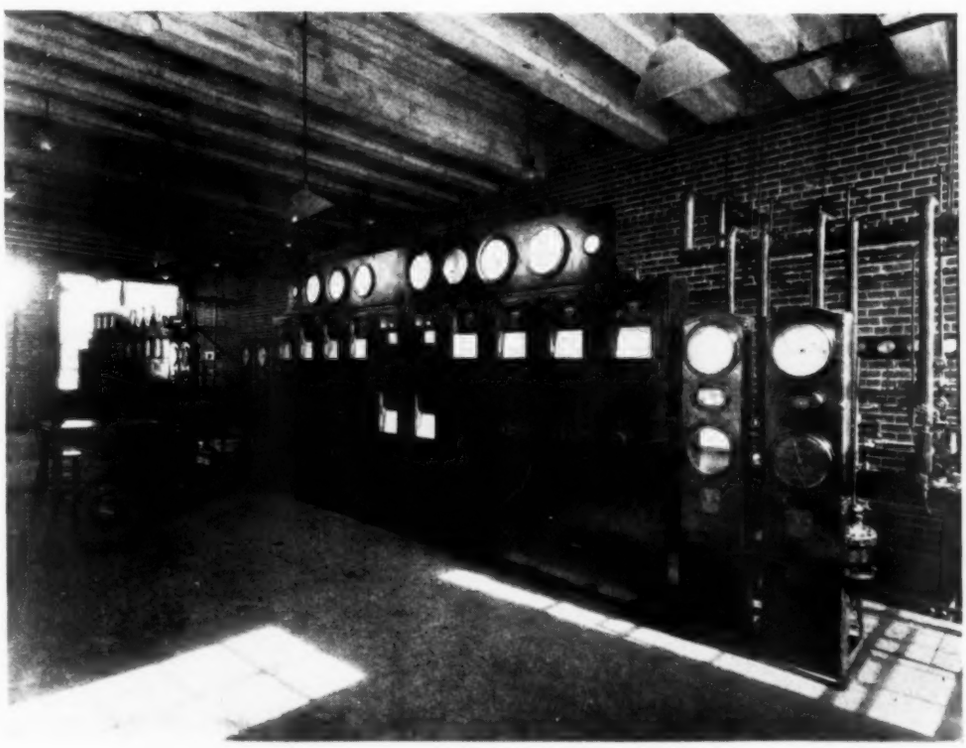
PRACTICALLY all phases of petroleum technology have shown marked progress in the past year, but there is probably no phase that has shown as great improvement as that evident in the new motor oils now on the market.

From the close of the World War until the year 1928 there was very little change in the various brands of motor oils marketed in this country. During this period such terms as "light," "medium" and "heavy" were of little value to the purchaser in obtaining similar grades of oil when, by necessity or desire, he wished to change to another brand. Toward the close of this period the need for better and more uniform grades of motor lubricants was beginning to be felt and as a step in this direction the Society of Automotive Engineers established their viscosity numbers. By means of these S. A. E. numbers the viscosity range, which was considered to be the most important specification, could be indicated along with the trade mark and grade name in order to more definitely describe the product.

The more progressive manufacturers of lubricating oils were quick to adopt such steps, particularly those who sell their products on a quality basis.

Another progressive step, and one of even more importance than the uniformity of viscosity as obtained by the adoption of the S. A. E. numbers, was a definite improvement in the quality of certain brands of motor oils. With highly anti-knock motor fuels becoming generally available throughout the country, practically all motor manufacturers increased the compression ratio of their motors and many also increased the speed of their motors. Automotive engineers had realized for some time that the greatest increase in efficiency of gasoline powered motors could be obtained through increase of the compression ratio but had hesitated in doing this due to the tendency of motor fuels to knock in the higher compression motors. The new anti-knock motor fuels, however, did not solve all the difficulties of the increased compression ratio. These new motors ran at higher temperatures and required more heat resistant lubricants than had heretofore been used. Up to this time blends of light neutrals with heavy stocks had been considered satisfactory oils as long as they met the viscosity requirements, but such oils were rapidly consumed in the new motors running at higher temperatures. These new motors then put another burden on motor oils. They must be heat resistant.

Much credit for the new heat resistant oils is due to Mr. L. A. Danse of the Cadillac Motor Car Company, who originated what is now known as the Cadillac Volatility test. High flash had already been used as a talking point by many marketers of motor oils, but the volatility test should not be confused with the flash test. An oil may give a low flash test simply because it contains a very small quantity of very volatile oils and the flash test is, therefore, a qualitative test. The Cadillac test, however, is a quantitative



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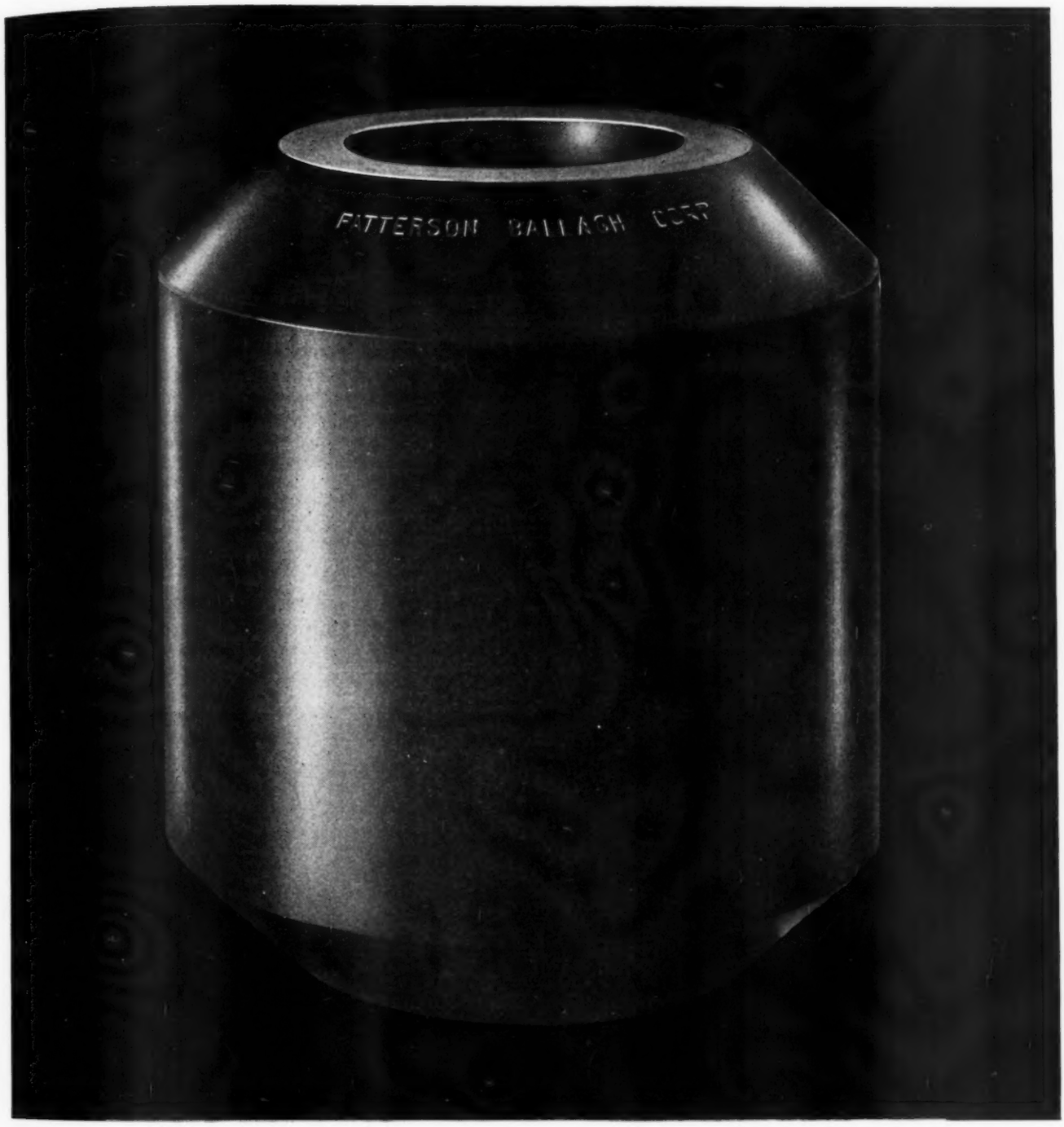

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test which shows the percentage of volatile constituents present. It is a distillation test under very definitely specified conditions. The initial boiling point may be reported as well as the per cent off at various temperatures, but the results are usually reported in terms of the per cent distilled off at 760 degrees F., the highest temperature to which the oil is heated in the test. An oil that shows only a small percentage or no distillate at this extremely high temperature must of necessity contain little or no light fractions.

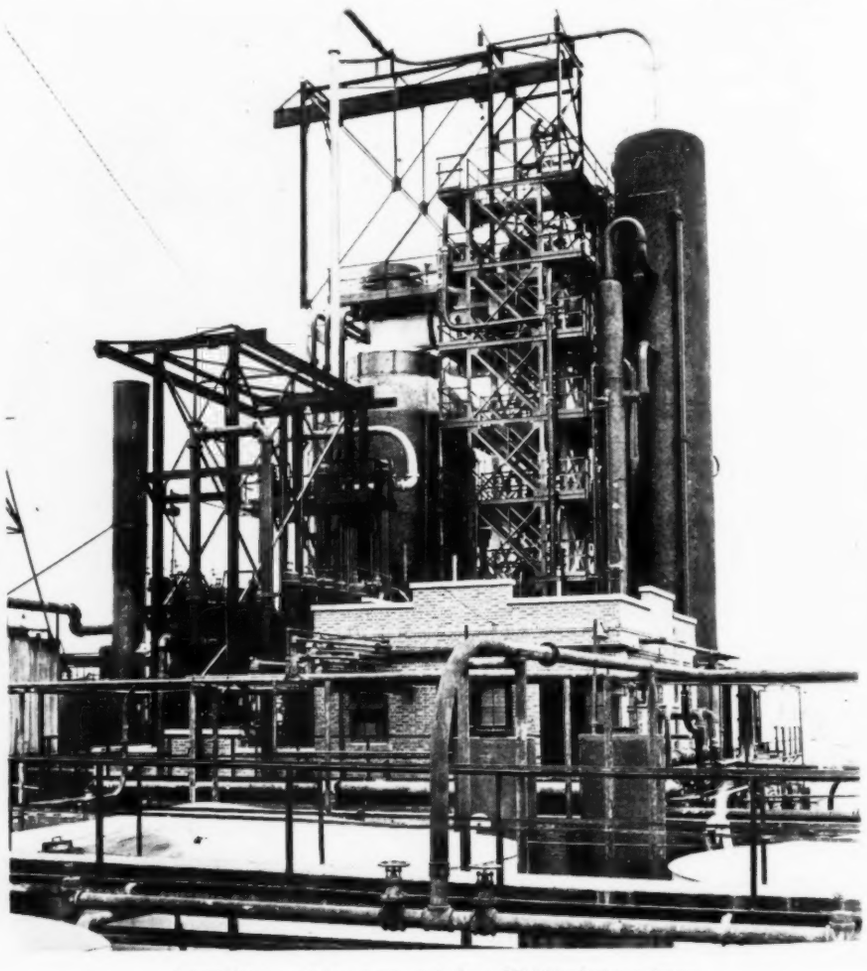
Some may advance the argument that no part of the motor reaches such extremely high temperatures, aside from the combustion chamber itself, but it must be remembered that the motor oil in service is repeatedly heated up and cooled down. While the oil may never reach a temperature of 760 degrees F., with the exception of that which reaches the combustion chamber, the repeated heating to somewhat lower temperatures time after time and often for long periods of time, has as great or greater tendency to break down the oil than does a single heating to 760 degrees F.

The claim has not been made that the Cadillac volatility test duplicates operating conditions in a motor any more than does the Conradson Carbon Residue test show the per cent of the oil that will be left in the motor as carbon. It is simply a comparative test between different oils as to their ability to resist heat and the results are shown on a definite percentage basis which indicates the amount of light, volatile fractions contained in the oil. Neither should the Cadillac Volatility test be confused with the carbon residue test. The carbon residue of an oil may be low but that is no indication of the amount of oil that will be consumed in the motor. In general the light oils are more rapidly consumed than the heavy oils though the light oils are usually lower in carbon residue. The carbon deposited in the motor is, of course, formed from the portion of the oil consumed. Mougey[1] states "The biggest problem we have in lubricating automobile engines in summer is excessive oil consumption at high speed and temperature."

Much of the trouble experienced with the first high compression motors placed on the market was probably due to the motor oils used. There were a number of motor fuels available at the time the high compression motors were first introduced that were sufficiently high in anti-knock properties to give satisfactory performance in these motors as they came new and clean from the factory, but the compression ratio of any motor is more or less rapidly increased when put in operation due to the accumulation of carbon in the combustion chamber. This tendency is aggravated by the fact that a great majority of the cars on the road are running with too rich a fuel mixture of which condition the drivers seem to be blissfully unaware.

The higher the compression ratio of the motor the more noticeable is the effect of carbon accumulation and the greater the tendency of the oil to break down and carbonize due to the higher operating temperatures. As an explanation of the more noticeable effect of the accumulation of a given amount of carbon in the higher compression motors, let us assume, as an example, two extremes which will illustrate this point more clearly. We will assume that we have two motors of the same bore and stroke but one having a compression ratio of 3 to 1 and the other a compression ratio of 6 to 1. We will also assume that both motors have been operated until the same volume of carbon has been accumulated in the combustion chambers and on the piston heads. Let us say that this volume of carbon in the motor of the 3 to 1 compression ratio represents one-tenth of the total volume of the combustion chamber when the piston is at the top of the compression stroke. Then the compression ratio becomes 2.9 to 0.9 or 3.22 to 1, which is an increase that would hardly be noticed in a motor of such low compression even when ordinary straight run gasoline is used as the fuel.

Now let us return to the motor of the 6 to 1 compression ratio. We have assumed that the bore and stroke of these two motors are the same for sake of comparison and therefore the volume of the combustion chamber of the higher compression motor, when the piston is at the top of the compression stroke, would be four-tenths of the combustion chamber volume of the 3 to 1 motor and the volume of the carbon which occupied one-tenth of the volume of the combustion chamber of the 3 to 1 motor would occupy 0.25 of the volume of combustion chamber of the 6 to 1 motor and the compression ratio becomes 5.75 to 0.75 or 7.67 to 1, which would most certainly be noticed through knocking and overheating unless an extremely high anti-knock fuel were used, such as the aviation ethyl gasoline in use by the War Department.



Atmospheric solution rerun unit in a Mid-Continent refinery.

[1] H. C. Mougey, "The Significant Properties of Automotive Lubricants." Presented before American Society for Testing Materials at Detroit, Mich.

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Maintenance of Electrical Equipment *in* Pipe Line Stations

By J. R. ASHLEY, *Magnolia Pipe Line Co.*

WITHOUT first obtaining a general idea of the electrical construction and the electrical materials used in our pipe lines stations, a discussion of their maintenance would be rather meaningless. Let us, therefore, draw a word picture of typical installations.

We have but two types of stations and they are as follows: plunger type pumps, driven by motors with short belt drive, and centrifugal pumps, driven by direct connected motors. The motors in both types of stations are standard squirrel cage induction, 3 phase, 60 cycle, 2,200 volt. The motors driving plunger pumps the 695 r. p. m. and those driving the centrifugal pumps are 3,560 r. p. m. Starting compensators for the former are manually operated, factory equipped with overload and undervoltage protection; for the latter they are automatic, solenoid operated with push button remote control, and have the same protection. The control for the centrifugal pump motors is mounted on a central control panel and the panel equipment also includes recording pressure gauges for the suction and discharge, and the pressure switches. The functioning of these pressure switches will be described elsewhere in the discussion.

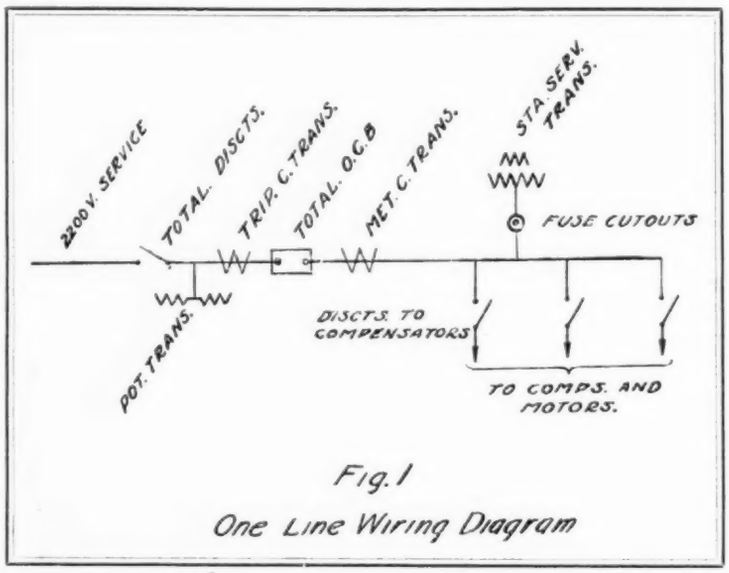


Fig. 1

One Line Wiring Diagram

A glance at the wiring diagram (Fig. 1) shows the circuit arrangement and the picture of a typical installation (Fig. 2) gives a view of the general assembly. From the picture it will be seen that all of the wiring is open and that branch circuit switching from the bus is done by means of disconnecting switches.

Totalizing disconnecting switches are 400 amperes, 15,000 volts, and branch circuit switches are 200 amperes. Both types are of unit construction and all parts are easily replaced. The totalizing oil circuit breaker is rated 400 amperes, at 7,500 volts, and is mounted on the switchboard framework directly behind the panel. It is an automatic breaker and controlled from the front of the panel. The bus is No. 4/0 solid copper with 5,000 volts varnished cambric and braided flameproof insulation. It is supported with pin type insulators from the disconnecting switch framework. Branch circuit jumpers are No. 1/0 solid copper with the same insulation as the bus. Protection of the electrical apparatus is provided by means of induction type overload relays and a time delay undervoltage device which trip the totalizing breaker. To prevent damage to equipment from overpressure, automatic pressure switches are installed in the pump discharge in both types of stations. The centrifugal pumps are also protected from loss of suction pressure and are automatically shut down when suction pressures reach a predetermined valve. Emergency stop stations are located at one or two advantageous places outside the building, by means of which the entire station may be shut down from without as might be required in case of emergency. From the compensators, the wiring is carried underground in conduit to the motors, 5,000-volt varnished cambric insulated lead covered cable being used.

In the construction of our stations it was decided that, since all motors were of the squirrel-cage type and all switching of loaded circuits was done under oil, it would not be necessary to provide separate compartments for switching equipment nor to provide firewalls between the motors and the pumps. With the type of equipment used there is little or no likelihood of fire originating from electrical causes.

Having obtained a fair idea of the details of construction and the equipment in these stations, let us now look at them from an operating standpoint. A typical schedule of maintenance is as follows:

MONTHLY INSPECTION

(a) Check all protective devices.
(b) Clean and adjust contacts, inspect oil level in compensators.
(c) Drain, wash and refill all motor bearings.
(d) Check all ground connections.
(e) Clean switchboard panel and rub down with oil.

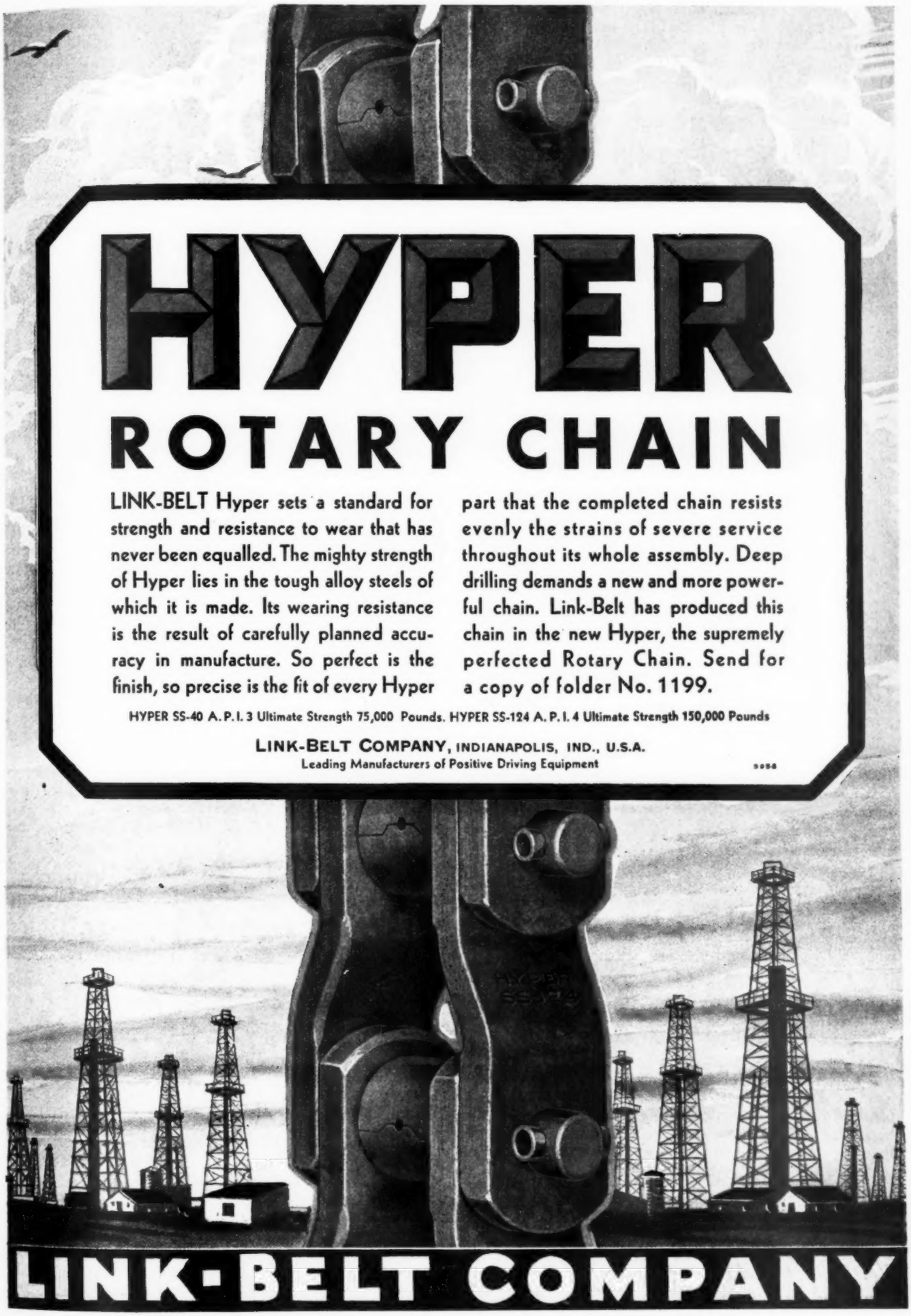
SEMI-ANNUAL INSPECTION

(a) Blow dust from motors.
(b) Check and calibrate all pressure control switches.

ANNUAL INSPECTION

(a) Clean and paint all busses and jumpers.
(b) Clean, polish and lacquer all exposed copper: disconnecting switch blades, etc.
(c) Clean and paint supporting frameworks.
(d) Inspect station service transformers.
(e) Test and calibrate all meters and switchboard apparatus.
(f) Inspect and change oil in all compensators and oil switches. Inspect contacts in totalizing oil circuit breaker.
(g) General overhaul of motors.

Daily cleaning of the apparatus is done by the operating engineers of the stations; however, the above schedule is carried out by regular electrical maintenance men, who make regular visits to each of the stations in their districts. In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addition to the duties outlined above, these men also clear all trouble and maintain and make extensions to station, residence, and tank farm lighting. Districts are so divided that these periodic inspections can be made regularly.

On the monthly inspections, tests are made of all protective devices. All of the major protection shuts the entire station down by releasing the undervoltage device on the totalizing breaker, and in checking their operation the breaker is blocked in the closed position and these tests are made without a shutdown. The compensator contacts are cleaned and put into condition and at the same time the motor bearings are inspected. This does not usually require more than a half hour to each unit, and where there is a spare unit (as there is in the majority of the stations), there is only a momentary loss of pumping time while changing units. Ground connections are checked and tightened with each visit to the station. The switchboard panel is thoroughly cleaned and wiped down with a cloth dampened in transformer oil. This increases the di-electric strength of the panel, reduces the absorption of moisture and also preserves the finish of the panel.

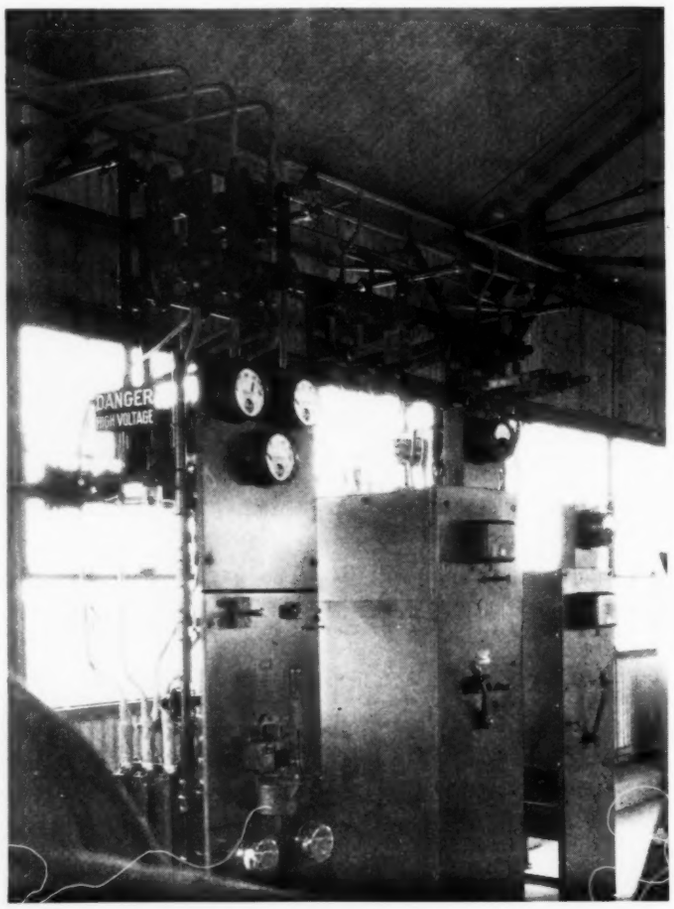


Fig. 2. Panel and control equipment.

Each division man is provided with a portable air compressor and twice yearly all of the apparatus is blown out. The motors and other inaccessible parts of the apparatus accumulate dust and this removes all dust that cannot be wiped from them. In localities where dust and sand storms are prevalent, this period is shortened and the equipment is blown out every three to four months. At this inspection all of the pressure control switches are carefully checked and calibrated with dead weight gauge testers. It has been found that calibration is not readily affected and a semi-annual test has proven to be effective.

The annual clean-up of the stations consists of a general and thorough cleaning of all electrical equipment. On these occasions additional crews assist the division men in the work. The busses and jumpers are thoroughly gone over and are given two coats of shellac and over this is applied a third coat of gray insulating paint. The supporting framework for both the switchboard and the disconnecting switches is also painted with a high grade of auto enamel.

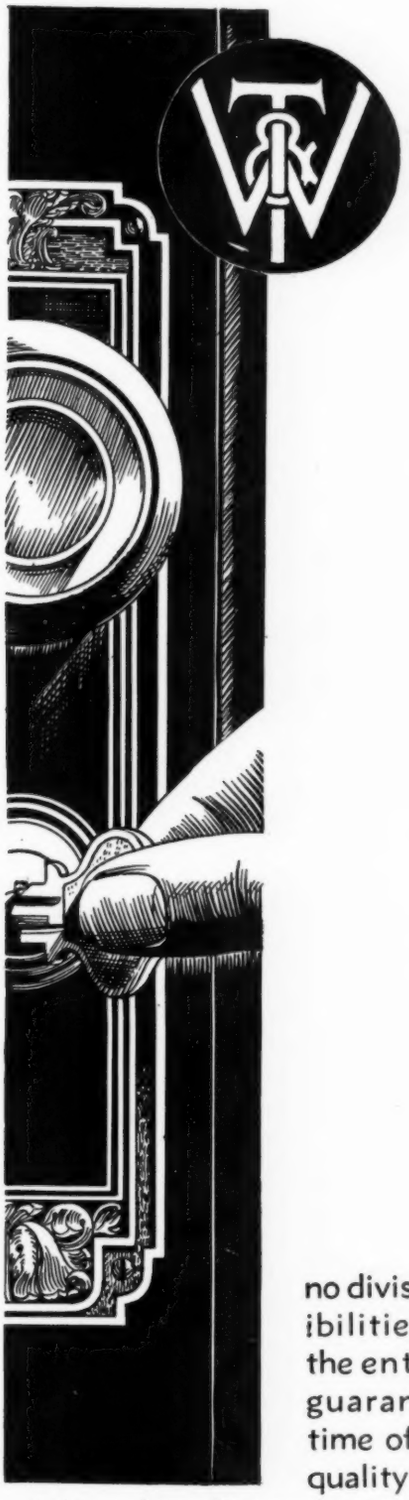
Due to the presence of corrosive gases in some crude oils, it has been found necessary to clean and polish all exposed copper, particularly the disconnecting switches. These switches are sanded down and polished, and, with the switch in a closed position, are given a coat of clear, acid and gas-proof lacquer. For this work a general shut-down of the station is required and all of the work on "live" apparatus is done with one clearance. The totalizing breaker is gone into, the contacts dressed and the oil changed. Due to the fact that no switching of loaded circuits is done with this breaker and its otherwise infrequent operation, no further attention need usually be given to it. The oil is also changed in the compensators and the switch tanks thoroughly cleaned at this time.

Little care is required of the station service transformers other than the painting of the tanks and draining and refilling with fresh oil each year. There is a slight accumulation of moisture in the tanks, but this is removed in draining. So far there has been no failure of these transformers.

All of the electrical metering for the station is done by instruments located on the face of the totalizing panel. The meters are as follows: voltmeter (with transfer plug for three phase reading), ammeter (with transfer jack), wattmeter (some panels are equipped with recording and others with indicating meters), and an integrating watt-hour meter. All of these meters are calibrated with test standards annually and at the same time the induction relays are also checked.

Particular attention is paid to the motors at this time. The rotors are pulled and washed down, the bearings checked for wear, and the windings are cleaned and painted. There is always a gradual accumulation of oil, especially in the lower parts of the windings. This oil collects dust, sand and grit blown into it by the fans and if left on the coils has two detrimental effects: it clogs the air ducts, causing poor circulation of the air and results in overheated coils; it also softens the coils and permits the penetration of oil and moisture, thereby weakening the insulation. The pulling of the rotors gives access to all parts of the windings and they are more easily and thoroughly cleaned. In cleaning these coils, gasoline is used where there is no fire hazard and carbon tetra-chloride where this danger exists. The gasoline is somewhat more effective and also much cheaper and can, with proper care, be used in nearly all cases. After the coils are clean and dry they are painted with an air-drying, acid-proof and oil-resisting insulating varnish. This varnish is applied by means of an air brush as this gives a more thorough coverage and reaches parts inaccessible to brush painting.

This maintenance schedule has been closely followed, and in several years of operation of over a hundred motor installations there have been but three cases of insulation failure, and these directly caused by lightning. We feel that the satisfactory and trouble-free operation of our electrical equipment has been the result of proper maintenance.



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The Manufacture *of* Lubricating Greases

By A. R. LANGE,

Chief Chemist and Production Manager, Swan-Finch Corporation

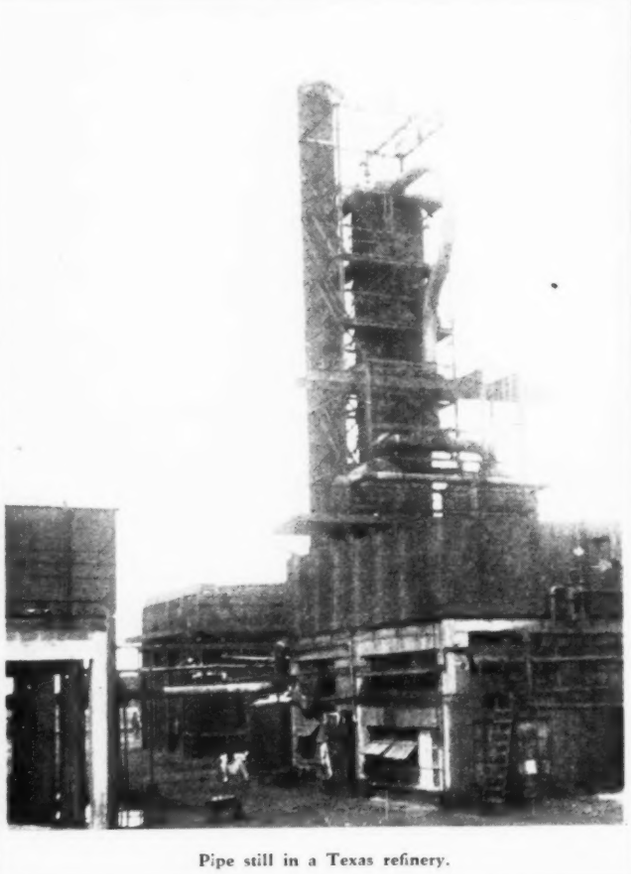
THE rapid strides that have been made in the petroleum industry as well as the automotive and mechanical world have had their effects upon the grease manufacturer. More chemists have become interested in the technical phases of lubricating greases and by close co-operation with designers and users of mechanical equipment have made their efforts worth while. New products have evolved and coupled with better control methods the chemist has been able to approach some degree of standardization whereby the ultimate consumer has been able to purchase by means of specification rather than by brand only. Formerly the grease maker, who generally lacked chemical training of any kind, had complete charge of a plant, not only controlling the manufacturing processes but the raw materials and quality of the finished goods as well. It cannot be disputed but that grease making is an art and that it has been developed to a high degree by such men, but too often their lack of technical training has been a detriment to the advancement of the industry and certain theories and practices crept into the manufacture of lubricants, especially lime greases that were not based on the chemical theory or nature of the compounds.

Within a limited sphere the chemist has always been a mainstay of the petroleum industry. He devised the tests and the instruments for testing by which products were standardized and did much definitely to advance the art of refining.

—Frank A. Howard.

Modern plants are now controlled in the laboratory. Raw materials are purchased on strict specifications and the processes checked throughout in order to produce uniform products. For example, when it is convenient to keep a batch of finished grease in a kettle at a temperature suitable for filling, tests must be run quickly and accurately. Kettles are equipped with thermometers so that a record may be had of the process and a standard procedure adopted which is best suited for a particular grease.

Greases when ready to be withdrawn are now pumped through screens under pressure, and into packages through an automatic filling machine, or they may be pumped to other kettles where other ingredients are added for special compounds. Although they are not as easy to handle as oil, they may be transferred much the same, only for shorter distances, and with straight lines avoiding bends as far as possible, and in some cases having steam jacketed pumps and lines. It is much cleaner handling grease in this manner than by the older method of straining into open head barrels through a box strainer.



Pipe still in a Texas refinery.

Many of the ideas conceived years ago regarding lubricating grease still persist, as for instance, that a lime soap does not add to the lubricating value of the grease, and that it is only as good as the mineral oil it contains—that horse fat makes a much better grease than other fats, and that if a lime soap is over-cooked it will not make a grease. Our knowledge of soaps as lubricants tend to contradict the first, and chemists will admit that a grease can be made from any fat, but that calcium stearate and oleate are more suitable for forming stable colloids than palmitic, or other acids occurring in some of the less common fats. It is also true that longer cooking will saponify a fat so completely that a grease cannot be properly made until some fatty acid is added, which gave rise to the over-cooking theory.

It was customary up to 10 or 15 years ago to use calcium oxide, or lump lime for grease manufacture instead of the hydroxide, or lime flour. This may have been due to the inability of getting a high content calcium hydroxide lime. The lump lime was purchased in barrels and quickly became air slaked and contained more or less unburned limestone, so that the calcium hydroxide content after slaking varied to such an extent that the grease maker had to use his own judgment as to the amount to use. The slaking and straining of the lime required several hours, besides the use of more water than was actually needed for saponification simply prolonged the time necessary to produce a low moisture grease. After saponification was completed it was necessary to slake lime in the afternoon for the next day's batches. With the introduction to the industry of a high content calcium hydroxide lime, this procedure has been done away with, and the lime can now be prepared in a few minutes, using no water, or just sufficient to effect saponification.

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The old method of determining the consistency of a grease by "feeling with the finger," and by comparing with a standard sample has been superseded by testing the grease at a given temperature, and after being broken down, or "worked" in a special cup, and testing by means of an asphalt pentration instrument, substituting a specially constructed cone for the needle. Such a cone has been perfected by the Grease Sub-Committee of the American Society for Testing Materials. By means of this instrument the depth to which a cone penetrates a sample of grease during a definite time is measured, thus making consistency numbers a numerical depth of penetration.

The American Society for Testing Materials has also adopted methods for the chemical analysis of such greases, such as the amount of combined fat, free fat, free lime, etc. The effect of such standard methods has brought greater harmony in the results obtained in the laboratories of both buyer and seller as the determinations are reproducible when performed by competent analysts.

There has been much stress laid on the melting point of grease for certain lubricating work, and methods for determining it are numerous, but none seem satisfactory, due to unreliable results when used by different operators. The American Society for Testing Materials has been working on this problem for some time as it is realized that a reliable method is badly needed.

The matter of melting point has been used as a football and any clarification of the term will be welcomed by the trade.

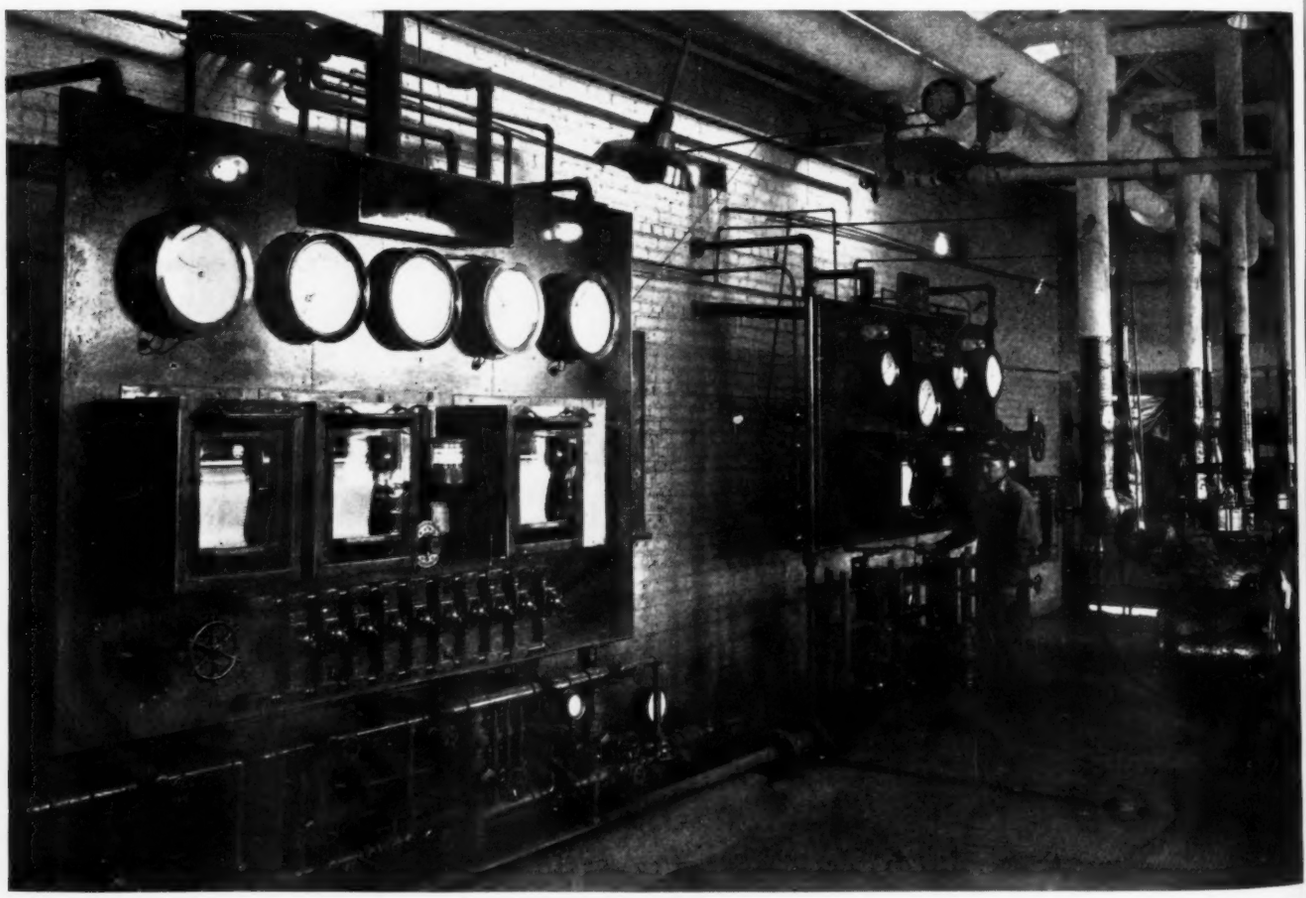
Greases are generally divided into several groups, such as lime, soda, aluminum, lead, etc. Lime grease, commonly known as cup grease, forms the largest class, with soda or fibre grease next. These greases are made from many kinds of fat, and mineral oils, and are used in many industries from heavy machinery, to textile mills. Each industry has certain requirements that the grease must fulfill, such as consistency, color, melting point, etc. Many textile greases are made from edible white fats and white mineral oils to prevent spotting if they come in contact with the cloth. Aluminum grease has found some application in certain lubrication problems, and lead grease has come into use largely for gear lubrication in automobiles.

With the introduction of one shot lubrication on automobiles there is need of a liquid grease to take the place of oil now being used, but such a grease must be able to pass through a felt filter without depositing the soap. Such a grease no doubt could be made. Although it has long been known that saponification is more rapid when conducted in an auto-clave, it is only recently that it has been applied in lubricating grease manufacture.

The soap is made in a separate kettle where an internal pressure of 60 to 75 pounds per sq. in. can be maintained, and it is claimed that saponification is complete in 30 to 40 minutes.

The soap is then run by gravity into an open, steam jacketed, kettle where the oil is added until the required consistency is obtained. The pressure kettle can be charged nearly full, and of a capacity so that more than one mixing kettle can be used at once, or the same kettle several times, depending upon the time required for discharging the finished grease.

In a pressure process saponification is so rapid, and the water so constant, that a uniform soap is formed each day, and with proper thinning with mineral oil a uniform grease is obtained, where in the open kettle cooking, the water may be evaporated more rapidly on some days than others, and saponification would vary accordingly, and not only affect the consistency of the grease, but its appearance and melting point.



Control room in the Kanotex refinery, Winfield, Kansas.

Polymerization as a Factor in Refining Processes

By BENJAMIN T. BROOKS[1]

EVERYONE today has a pretty good idea of what "cracking" is, or at least of the ways it is done and the final results; polymerization may be regarded as the reverse process, i. e., the coupling up of two or more molecules to form a more complex material. Thus, tars and pitches, coal, coke and rubber are polymerized products. Lubricating oils and probably asphalts have resulted from this coupling-up process, and large proportions of the more volatile fractions of petroleum may possibly be the result of such a process.

In the coupling up of a simple sugar to form the cellulose of cotton or wood fibers, or the conversion of silicic acid to common quartz sand, aluminum hydrate to bauxite, the ruby or the sapphire, and in the manufacture of Bakelite or similar familiar synthetic resins, water is split off during the coupling-up process. But in the case of the unsaturated hydrocarbons, we have polymerization reduced to its simplest terms; that is, nothing is split off during the process. This, then, is true polymerization.

Polymerization and the Formation of Petroleum.

The more we learn about petroleum, the farther away we get from some of the theories which have been proposed for the origin of petroleum. Probably all geologists and certainly most chemists no longer regard the theory of the origin of petroleum from metallic carbides by the action of water as a plausible theory. Probably the most generally held idea, however, is the theory, largely due to Engler, that petroleums have been formed by the destructive distillation of animal or vegetable remains, or more specifically the natural fatty oils or their fatty acids. It is true that heating fats or fatty acids, under pressure to get the necessary high temperature, does give a distillate containing a mixture of hydro-carbons somewhat resembling petroleum; it is fluorescent, contains wax and may be redistilled into fractions resembling gasoline, kerosene and gas oil. Geologists have been inclined to accept the destructive distillation theory as it gives sort of a rough and ready explanation for the transfer of the oil from a "source rock" to a sand.

Advocates of the destructive distillation theory generally ignore or are not aware of the many facts which strongly negative such an unnatural mechanism. In the first place every petroleum technologist knows that natural petroleums consist largely of saturated paraffins, naphthenes and polynaphthenes and small percentages of aromatic or benzenoid hydrocarbons; they do not contain appreciable or detectable proportions of unsaturated, "cracked" or olefinic hydrocarbons such as are characteristic of destructive distillation products. But there are more serious objections than this. The processes of heat decomposition described by Engler and his later followers, yield, in addition to methane and the simple paraffins, substantial percentages of carbon monoxide and hydrogen, both of which are entirely absent from natural gas associated with petroleum.

As for the geological evidence there is nothing to support the heat decomposition theory and a great deal that is strongly against it. For example, the maximum temperatures, about 150 degrees F., recorded at the bottom of our deepest wells are far short of the temperatures required to produce detectable cracking or thermal decomposition of either the fatty acids or hydrocarbons, even at atmospheric pressures; and the effect of high pressure is generally to prevent such decompositions which occur with increase in volume, according to the well-known principle of Le Chatelier. It should also be remembered that many of our well-known oil fields derive their oil from very shallow sands, less than 2,000 feet in depth, usually very little disturbed or folded, thousands of miles away from igneous instrusions or other actual evidence of heat sufficient to cause the changes required by the heat decomposition theory.

Dr. Benjamin T. Brooks is one of the foremost American petroleum chemists. His "The Non-Benzenoid Hydrocarbons" is a classic in petroleum chemistry. The author believes that more research work and study should be given to the process of polymerization in order to have complete flexibility of refinery production.

It is true that "catalysts" have been mentioned in this connection. Thus anhydrous aluminum chloride has been seriously mentioned in such discussions, also the hydrogenation catalysts such as finely divided nickel or platinum. But of course no such substances have ever been found in the sedimentaries, much less widely disseminated in them as any agent must be that has been a factor in the origin of petroleum. In other words, heat decomposition is just as unnatural and subject to just as weighty objections as most of our other laboratory methods of hydrocarbon synthesis such as the Grignard reaction with metallic magnesium, or the Wurtz-Fittig reaction with metallic sodium.

It has been calculated, with the usual wizardry of mathematics, that folding of thick strata can produce a great deal of heat, but what becomes of such heat formation spread out over a few million years and among a few billion tons of rock? It may also be objected that under very high pressures hydrogen, if present, may actually combine with unsaturated oils, as in the Bergius-Standard Oil process; but what of the petroleum found in very recent and very shallow muds and slimes, lacking both the pressures and temperatures of such processes? If, it is argued, that any of these things can happen at very slow rates during the long sleep of geologic time, then of course that takes the matter outside the range of our observation and experiment.

Probably the way to study the origin of natural products is to study natural processes. So far as our very limited observation goes, we find normal heptane formed in several living plants, and crystalline paraffin waxes in several score

[1] Consultant on Petroleum Products and Refining.

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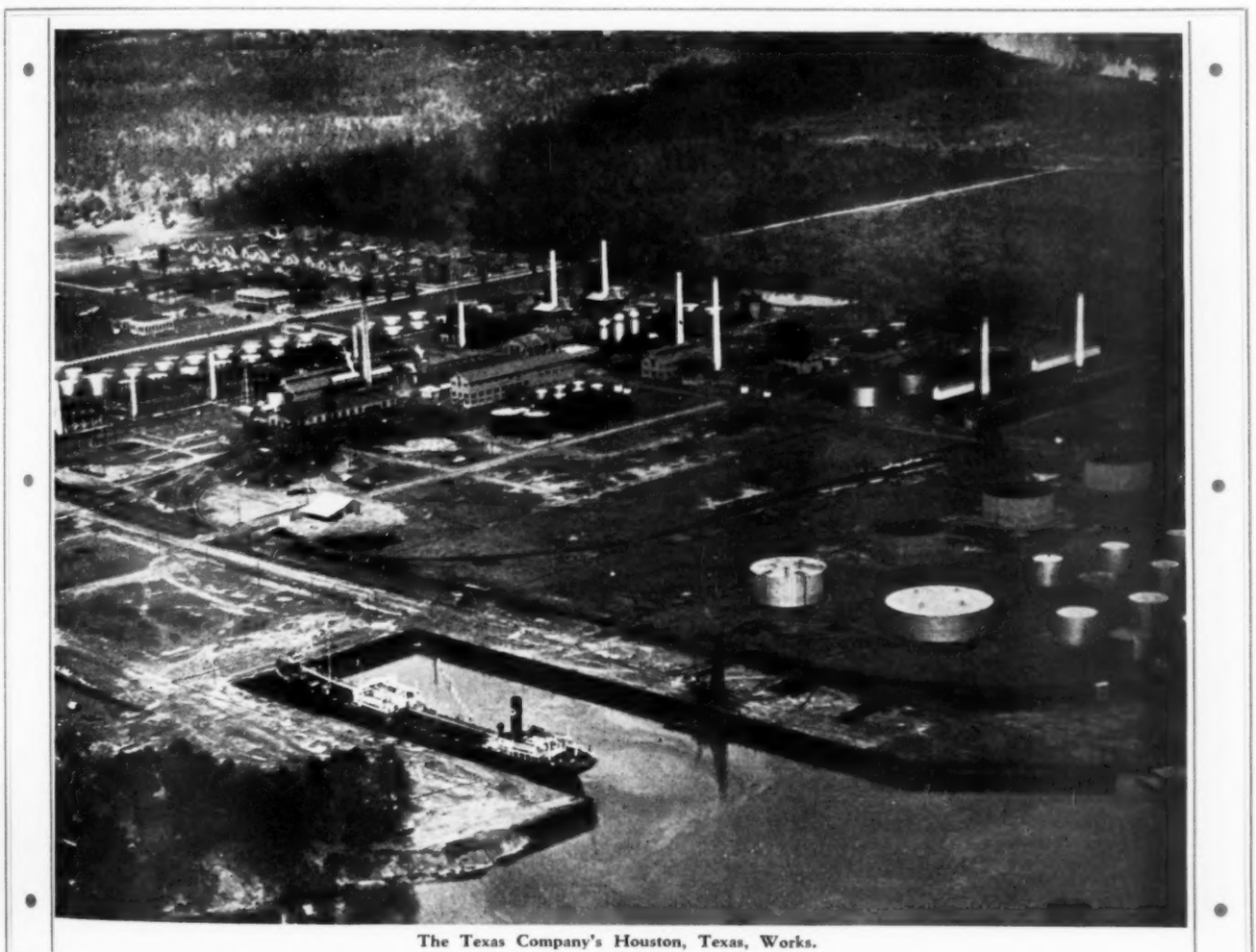
of plants, including the fragrant rose (rose oil looks not unlike chilled wax distillate), and methane as a product of several natural fermentation processes, just how or by what chemical mechanism we do not know. We know bacteria that will reduce sulfates and deposit free sulfur, others that will feed on sulfur and oxidize it, others that produce hydrogen sulfide, as every small boy knows — but what happens to the natural fats or fatty acids under the natural anaerobic conditions of material laid down with, or covered with clay or mud we have not the slightest idea. Apparently nobody has ever tried to find out if in the well-known fermentation of cellulose to methane, ethane or other hydrocarbons are formed. It was a small percentage of ethane in the methane produced by the catalytic reduction of carbon monoxide that led to the development by Patart and Fischer of synthetic gasoline process, from water gas.

But, if petroleum has been formed from natural fats or fatty acids by bacterial action, or even by heat decomposition, we cannot account for the heavier fractions of petroleum, the lubricants, without the aid of some coupling up process or polymerization. Thus the common fatty acids contain only 16 to 18 or in rare instances as many as 22 carbon atoms, so that if we eliminate CO_2 by any process, the resulting hydrocarbon would still belong to the gasoline or light kerosene oil class, unless it is coupled up or polymerized. As to how we can get the large series of the still lighter or simpler hydrocarbons, the correct answer it simple; nobody knows. But we do know how we can effect the coupling-up process, by materials naturally occurring widespread in the sedimentary rocks.

Fullers earth has been known to the refiner for generations. But nobody knows how or why it produces the results which characterize it as Fullers earth. This particular clay is found generally in quite restricted localities and has seldom, if ever, been found actually associated with petroleum. If polymerization has actually been a factor in producing the lubricants and other higher boiling fractions of petroleum, including even gas oil, then the activity of typical Fullers earth must be common to other widely disseminated minerals. Through the courtesy of Professor Gould and Professor Padgett of the University of Oklahoma, who furnished the specimens, the writer has examined a score or more of the sedimentary rocks of Oklahoma, including sandstones, limestones and shales. Pronounced ability to cause the polymerization of certain hydrocarbons was common to all of them, and several—the Sylvan shale, the Red Beds clay and Tertiary clays—were nearly equal to the best grades of Fullers earth. The Stanley shale, Reagan sandstone, Gray Permian sandstone and the Calvin sandstone also showed this property to a high degree. Greensand from Texas and from New Jersey, and a soft variety of bauxite were equal to the best Fullers earth. The Permian sandstone, Simpson sandstone and Stuart shale of Oklahoma also showed this property, but to a less degree. It may be of interest to note that Bentonite and kaolin showed only a very slight effect, and that infusorial earth, powdered pumice and the hydrous silicates (dehydrated) such as talc, and the zeolites produced no effect whatever. Silica gel and "glaucosil" (acid leached greensand) showed only slight activity. The cause of this behavior is undoubtedly bound up in some manner with the physical structure of the



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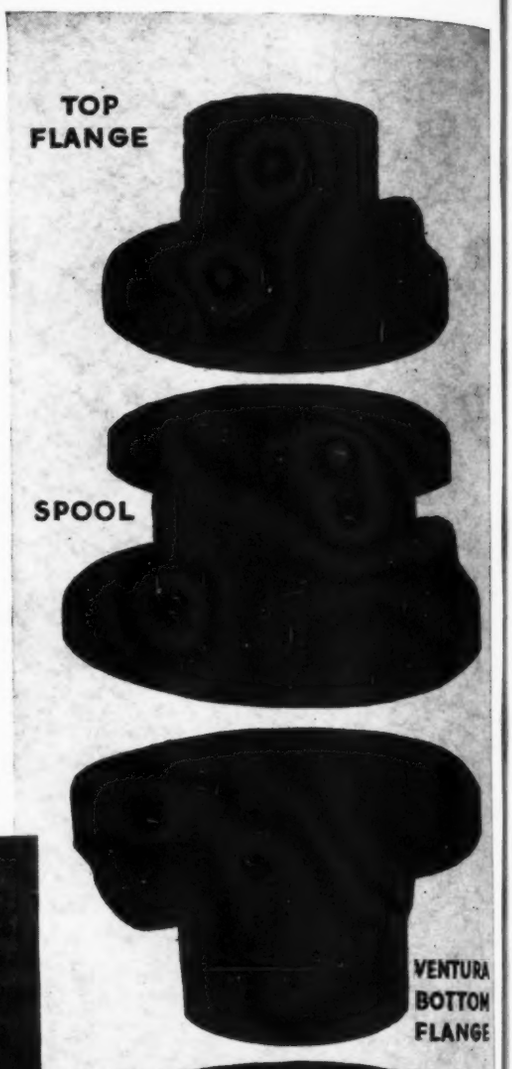

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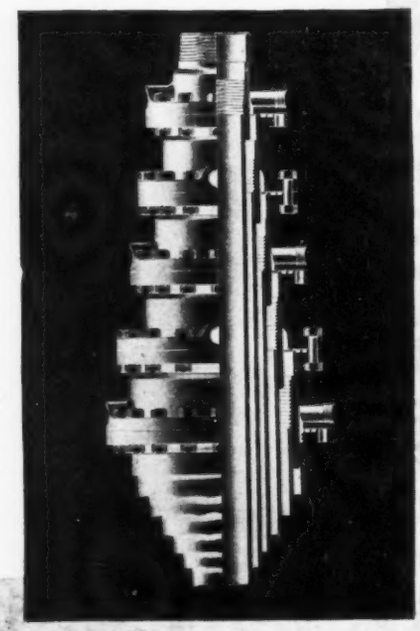

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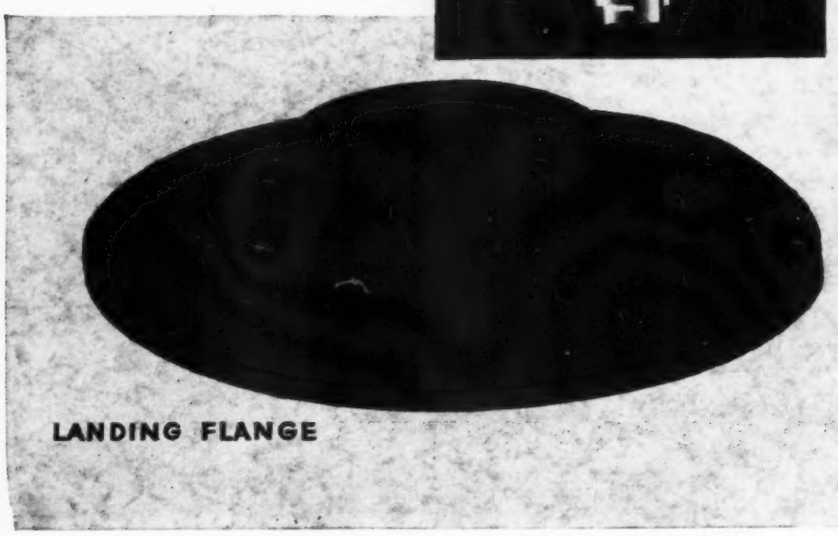

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material, but the interesting fact is that the sedimentary rocks, of widely different character, possess to a marked degree the ability to couple up unsaturated hydrocarbon oils, to more complex oils. Such a process would account for the gas oil and lubricant fractions found in natural petroleum.

Polymerization in Cracking Processes

Most of our knowledge of the polymerization of hydrocarbons by heat is limited to a few academic observations on the polymerization of ethylene and a few other simple olefins under heat and pressure. Ethylene, probably the most stable of the olefins, is very rapidly polymerized under pressure at 380-400 degrees C. to a mixture of oily hydrocarbons. It will be noted that this is below the temperatures commonly employed in cracking. It is to be expected that other olefins will be polymerized with equal rapidity at still lower temperatures. No investigation of this wide range of possibilities has ever been made, or at least published. Most of the simple dienes have been investigated in connection with the problem of making synthetic rubber; butadiene readily polymerizes at 100 degrees C., isoprene not quite so readily; allene is slowly polymerized at 140 degrees C., and diallyl slowly at 250 degrees C.

In commercial cracking processes, which initially must produce a highly unsaturated light hydrocarbon mixture, the temperature is stepped down in various ways, from about 900-950 degree F., to atmospheric temperature, thus passing through the temperature ranges where polymerization is known to occur. Many common observations indicate that in cracking operations this is an important factor deserving of some special study. In high temperature cracking of the vapor phase type, yielding a very unsaturated gasoline, it is sometimes the practice to "shock cool" the cracked vapors, as otherwise the yield of gasoline cut is diminshed and the character of the gasoline is altered.

This is shown clearly by the following experimental work. A typical highly cracked vapor phase distillate, unrefined, gave a very yellow gasoline distillate, to 400 degree F., and its highly unsaturated character was also indicated by the heat evolved on treating with sulphuric acid. After heating in an autoclave for three hours at 600-680 degrees F., the gasoline distillate to 400 degrees F. was 24 plus color and much less reactive to sulphuric acid; the gasoline cut of the original material gave a temperature rise of 83 degrees F., and the heat treated gasoline a rise of only 23 degree F., when both were treated with 10 per cent concentrated sulfuric acid. This large proportion of acid was used merely to compare the unsaturation.

The polymerization of highly unsaturated material can be shown to occur in commercial cracking equipment, the time interval during whlch oil is held in the so-called reaction chamber and fractionating tower, particularly where the fractionation is done under pressure, being sufficient to produce noteworthy results. Thus in one case noted by the writer, two units of a well-known cracking process were run as nearly as possible under the same operating conditions, same stock and same transfer temperatures. One unit was equipped with a small fractionating tower which met all the expectations of its designer with respect to the physical character, end point, etc., of the overhead gasoline product. The other unit carried a much larger tower, well insulated, and carrying about three times the hot oil in the tower as the smaller column. The large tower, in which the time interval through the polymerizing temperatures was much greater, gave an overhead gasoline of 25 color, 190 mg. of gum in the unrefined condition, and treated very easily to give a satisfactory product. The smaller tower gave a gasoline of the same end point, but 10 color and showed 536 mg. of gum, before refining and naturally gave much more trouble on refining. The difference in color and gum was due to the greater removal by polymerization in the larger tower, of the highly unsaturated and more easily polymerized constituents, not to impurities carried over by imperfect fractionation by the smaller tower, as was proven by further study of these distillates.

The actual loss of cracked gasoline hydrocarbon caused by the polymerization of those highly unsaturated hydrocarbons which oxidize rapidly to form gum may be very small indeed, as is shown by the refining loss resulting from refining a typical cracked gasoline by the Gray method, in which the hot vapors are passed through Fullers earth.

While it is generally recognized that higher operating pressures yield cracked gasoline of better initial color, less rapid gum formation and easier to treat to satisfactory stable gasoline, the most convincing comparative results are those published recently by De Florez. In the De Florez unit it was possible to make a series of runs at the same temperature but at various pressures.

Effect of Pressure on Character of Gasoline.

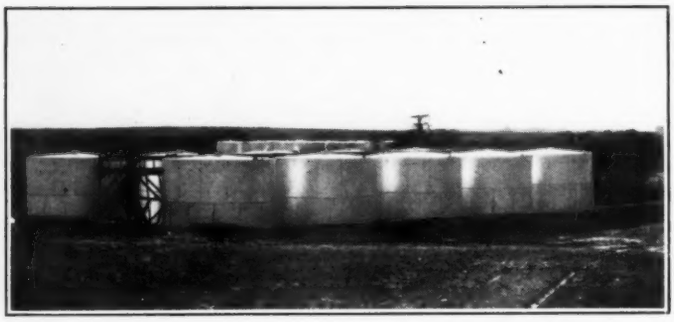
Operating Pressure	15 lbs. per sq. in.		80 lbs. per sq. in.		100 lbs.
A P. I. Graitvy....	52.7	52.9	52.7	53.8	57.1
End point °F.....	397	380	406	390	371
50 per cent point °F.	274	276	300	284	248
Color (Saybolt)....	yellow	yellow	+7	0	+15
Gum (copper dish)	604	576	.....	207	110
Anti-knock rating	32	33	32	33	35

As noted above in the comparison of the results obtained with a large and small fractionating column in connection with cracking, time is an important factor in producing polymerization. This coupling up of highly unsaturated material by heat, after leaving the cracking coils, acts like a *refining* process, that is the results are much the same as when the refining or polymerization is done by the action of Fullers earth or sulfuric acid. Also the operation of the fractionating towers under pressure favors this polymerization or cleaning up process since the oil or pressure distillate in such towers is at a higher temperature than when the vapors are released to atmospheric pressure before fractionation. Thus, in the Holmes-Manley cracking process it has been customary to fractionate the pressure distillate under the full operatng pressure of the cracking process. One of the advantages of such a procedure is to produce a gasoline of about 25 color which is very easily treated, due to partial polymerization of the unsaturated hydrocarbons in the tower.

In a recent paper by S. A. Kiss it is stated that the discrepancy between the calculated and obtained values, in cracking to gasoline, becomes considerable when the time is prolonged "owing to the formation of heavy polymerized products and coke from certain highly unsaturated cracked products in the gasoline range." The excessive formation of coke formed when hot residuum is allowed to remain in the so-called reaction chamber is to be regarded as a kind of polymerization.

Polymerization in Refining Processes

When cracked gasoline was first produced in large quantities it was quickly realized that concentrated sulphuric acid caused large losses by polymerization unless the proportion of acid used was reduced to 3 pounds or less per barrel. The use of acid less concentrated than 66 degrees, suggested by Ellis, and the use of chilled acid introduced by



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Halloran had the result of reducing loss by polymerization. As ordinarily carried out, this loss of gasoline by polymerization is not important except in unusual cases such as certain vapor phase gasoline, or cracked gasolines very rich in sulphur in which case the loss of gasoline by acid treatment may be as much as 15 per cent of the raw gasoline treated. The polymers formed by either acid or Fullers earth are not all of such high boiling point as to be lost to the gasoline cut. In fact some effort is now being made to convert the unsaturated gaseous hydrocarbons now lost or burned as fuel to gasoline. Thus certain of the polymers produced from the amylenes and butylenes have an anti-knock value in gasoline blends, equal to 3 to 5 times the value of benzole.

Considerable effort is being made to convert methane, and more particularly the ethane, propane and butane, of natural gas to gasoline hydrocarbons. This is in effect a process of polymerizing the initial unsaturated products, formed by cracking such gaseous paraffins, to liquid polymers suitable for motor fuel. One of the principal hydrocarbons so produced is benzole, believed to be formed by coupling up the acetylene first formed. While such recations are generally regarded as "cracking," the cracking is the first step, and without polymerization the desired products could not be obtained. In such processes heat has been relied upon to effect the polymerization.

In the refining of lubricating oils some polymerization occurs, but the results of polymerization, which forms more viscous and heavier oils from light ones, is obscured by the removal of much of the heavier oil as tar or sludge.

The conversion of light, thin oils into viscous oils by electrical methods of polymerization is carried out in Germany, the process being known as the Voltol process. Anhydrous aluminum chloride has been used for accomplishing such a result, to give pale, wax-free lubricants of increased viscosity.

An experimental reorganization of the British Patent Office is under way and the examining staff is being increased. In the United States, Congress is considering an increase in the number of examiners in the Patent Office in an effort to lighten the burden under which the present force now labors and to reduce the present delay and drag upon American industry.

Old Motor Oil Put to Good Use

Used motor oil, the drainage from the crankcases of the country's 26,000,000 motor vehicles, is being put to work.

Farmers of California collect it from garages and filling stations to use as a fuel for burning stumps and farm debris. In a suburb of New York it has been used to keep down mosquito pests in swamp areas by pouring it on the pools

The city of New Bedford, Mass., is planning to collect the oil regularly and use it as fuel for the city incinerator plants. It is believed that the city not only will save money, but will be rid of difficulties encountered in disposing of the old oil.

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Reducing Corrosion *in* Pressure Still Equipment

By J. T. DICKINSON[1]

A LARGE amount of work is being done and numerous articles published on the problem of reducing corrosion in cracking equipment. Of the successful methods actually in use apparently the most common is that of adding lime to the charging stock.

As pointed out in one paper* recently, when lime is added in this way part of it collects in the coke, but where a liquid residuum is drawn off a majority of the lime comes out with this residuum. The presence of the lime, of course, increases the normal BS content of the residuum, usually bringing the BS to the point where part of it at least must be removed in order to meet market specifications for fuel.

When fuel containing the lime is burned, the lime collects as a dust on the tubes and in the flues, where it acts as an insulator, preventing proper heat transfer. In some cases the lime also tends to flux the fire box linings unless special materials are used to resist such action.

If the residuum is kept warm and held in storage for some time a considerable portion of the lime will settle out, but this method has the disadvantage of tying up storage and still leaving the necessity of cleaning the tanks periodically to remove the settled material. It is also somewhat uncertain in operation and cannot be relied upon to effect a complete removal of the BS.

Filtration of the residuum as drawn from the stills has been used successfully in several refineries for a number of years and it is believed that the following description of equipment used and results secured will be of interest to any refiner now using, or contemplating the use of, lime. A practically complete separation of the solids, both lime and carbon, is secured, and the method has the advantage of sending only clean oil to storage and of discharging the solids in a dry condition in which they can be readily handled.

[1] Oliver United Filters Co.

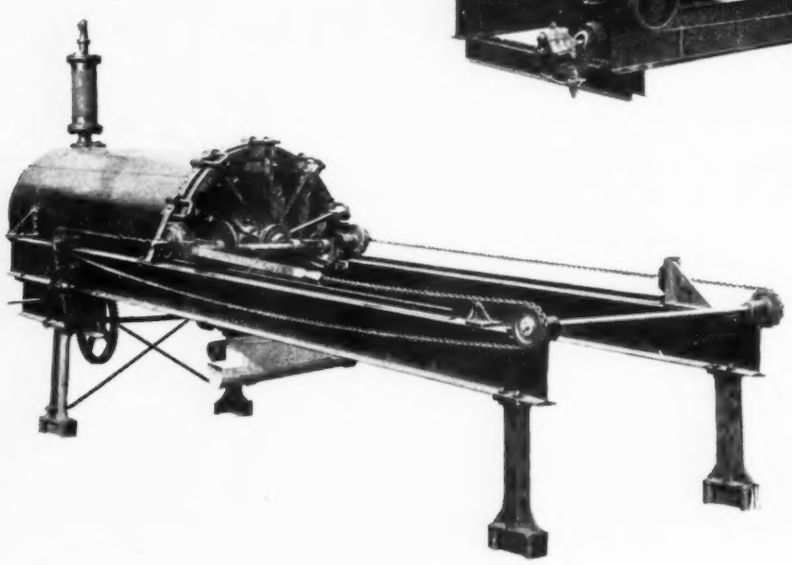
* "Pressure Still Corrosion," by W. G. Whitman and J. K. Roberts, Tenth Annual A. P. I. Meeting, December 4, 1929.

Type of Filter Used

The pressure leaf filter, as specially modified for this work, is the filter in general use. The cylindrical steel shell is built with an ample factor of safety to operate at 100 pounds pressure, and the quick-closing and self-locking head is of cast steel. Leaves of steel construction are spaced on 4-inch centers to allow the formation of cakes approximately one inch thick. Opening and closing of the filter is done quickly and without manual labor by means of an air motor mounted on the filter frame. A tongue and grooved joint is used between the head and the shell with a special gasket allowing operation at temperatures as high as 700 degrees Fahrenheit. The individual leaf outlets are manifolded outside of the filter head into a filtrate header from which the filtered oil goes under filter pressure either through a cooler or direct to storage.

Filter Operation

The filter operates on the batch principle. The hot residuum is fed to the filter under pump pressure and, after the shell has been filled and filtration started, the pump pressure is maintained until a cake approximately one inch thick has been formed upon the filter leaves. This requires from 30 minutes to two hours, depending primarily upon the amount of solids in the unfiltered residuum.



After a one-inch cake has been formed the pump pressure is reduced and steam pressure applied to the filter shell. Feed is then shut off and the excess oil in the filter forced back to the feed tank under steam pressure and the cakes dried by allowing the steam to pass through them. The steamings are usually sent to a small slop tank with vent to the atmosphere

Top—Filter in an open position. Below — Filter in a closed position.

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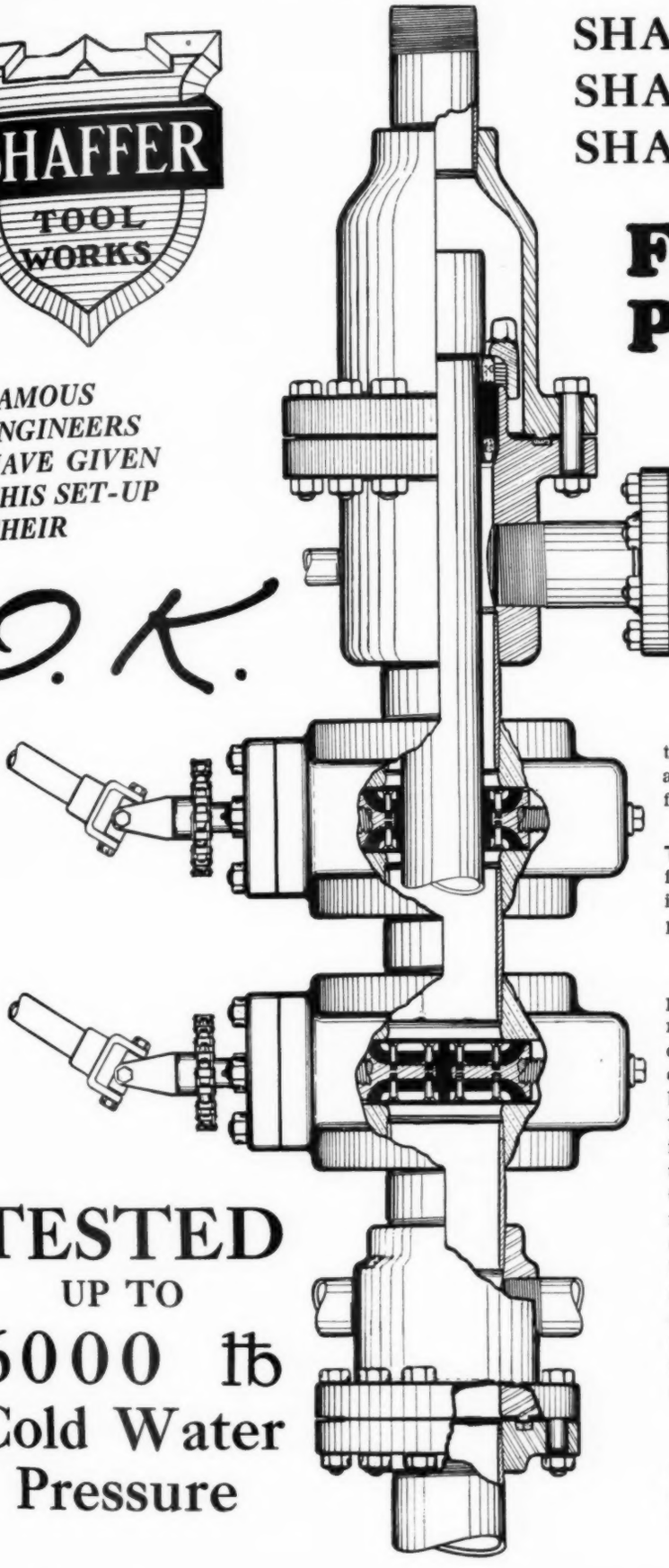

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BY HAVING the Warren Control Head in place on the well and Christmas-tree connection made up on the top cap and set in a convenient position on the derrick floor, the driller can pack off his drill pipe and close in his well, the whole operation taking only a few minutes. The Warren Control Head is furnished for any size casing, drill pipe, kelly or tubing. Overflow connections can be built into the body of the Warren Control Head, or a separate high-pressure Shaffer cellar cross can be furnished.

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With this control gate, a shut-off can be made even when the well is flowing. It eliminates attempting to place packing in a blow-out preventer when the well is out of control.

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so that most of the steam will pass off and prevent accumulation of water in the filtered oil. Where filtration is carried out at temperatures materially above 300 degrees Fahrenheit, the steaming performs the additional function of cooling the cake to steam temperature, thus reducing the likelihood of the cakes catching fire when later exposed to the air.

After steaming the cakes the filter is opened, the cakes discharged, and the filter closed for another cycle. The following represents a typical cycle and shows the division of time for different operations:

Filling shell and clearing streams	5 minutes
Filtering	90 minutes
Draining shell	5 minutes
Steaming	20 minutes
Discharging	15 minutes
Total cycle	2 hours 15 minutes

Filter Capacities

Filter capacities are usually rated in gallons of filtered oil per square foot of filter area per hour. On this basis the average rate being obtained commercially is approximately 4 gallons. This is equivalent to 96 gallons, or about 2¼ barrels per square foot per 24-hour day.

The filters are, of course, built in different sizes, but the size in most common use is that which has a total area of approximately 450 square feet. At the above-mentioned average capacity the unit will thus handle approximately 1,000 barrels of filtered oil per day. Where the capacity required is less than this figure, a smaller filter is available, and where greater capacity is desired it is obtained by the installation of two or more units.

Efficiency of Removal of Solids

It should perhaps be made clear that filtration of the residuum removes only material such as lime and carbon which is actually solid at the filtering temperature. The so-called "asphaltenes," which are insoluble under some conditions, are usually in solution when filtered and pass through with the filtrate. The asphaltenes may temporarily come out of solution later, but are apparently entirely satisfactory as fuel and should therefore remain in the filtered oil.

The benzol centrifuge test, ordinarily used for determining BS on fuel, usually shows only actual solids and keeps the asphaltenes in solution. This test is therefore a proper measure of the efficiency of the filtering operation.

Residuums being handled today vary from around 3 per cent to as high as 15 per cent BS by the centrifuge test. The filtered oil seldom shows more than ½ of 1 per cent BS, and by careful operation can be kept to a bare trace.

Extent of Use at Present Time

There are at present about 42 filters installed in six different refineries with an aggregate capacity of approximately 42,000 barrels of filtered oil per day. Since, as previously stated, a number of these filters have been in operation for several years, it will be readily appreciated that this is a well-established method producing results on a commercial scale.

As a successful and satisfactory method for removing the solids from the residuum, filtration thus eliminates the most serious disadvantage of using lime and contributes materially to the general problem of combating corrosion in cracking still equipment.

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SOME ASPECTS *of* » » »
Operation *of* Carbon Black Plants

By T. D. CABOT, *Godfrey L. Cabot, Inc.*

A CASUAL investigation of the carbon black industry would lead one to believe that the manufacture of carbon black is a very simple process. Natural gas is burned, the flame allowed to play on a metal surface, and the soot continuously scraped and collected. When one considers that ordinary soot collected in a chimney has no value, whereas only 10 cents' worth of a proper carbon black triples the life of a tire costing over $10, the problem appears less simple. When one learns that two samples of carbon black made in the same factory under conditions which the operator thought identical may vary in rubber reinforcing properties by nearly 100 per cent, the problem seems decidedly complicated.

The author of this article is a member of the firm of Godfrey L. Cabot, Inc., one of the oldest and largest manufacturers of carbon black in the United States.

Carbon black is not simply carbon. If it were, we could obtain approximately the theoretical thirty-five pounds per thousand feet of gas which an analysis shows the gas to contain. Carbon black is probably a mixture of hydrocarbons. Although we can determine its ultimate analysis, we don't know what compounds are present.

In appearance carbon black is a light black powder, dry, but somewhat flocculent. The individual particle is too small to be seen in the highest powered microscope; in fact, it is probably much smaller than the wave length of any visible light. Hence we can have no knowledge of its average size, shape or appearance. We can only make assumptions as to its characteristics from the observed properties of the pigment.

The manufacture of carbon black of a definite quality has been, and to some extent still is, a hit-or-miss proposition. Formerly, when carbon black was used almost wholly for coloring, certain general principles were developed as to the relationship between operating conditions and color. It was learned, for instance, that smaller tips, also, within limits, stronger gas flow, and more ventilation, improved the color but cut down the yield. It was learned, too, that the fluidity of a paste made from a given amount of oil and carbon black decreased with improvement in the color.

Today 72 per cent of the world's carbon black is used as a reinforcing agent in rubber, where color is of no real interest. The exact reason for this remarkable property of carbon black in increasing the tensile strength, abrasive resistance, etc., of rubber compounds is not known. Therefore, we can only cut and try in attempting to improve the properties of carbon black for rubber purposes.

The overproduction of carbon black in the last few months has greatly stimulated the efforts of producers to improve the quality of their production for rubber. Every important carbon black company has a technical staff headed by an eminent rubber chemist. Some of the larger companies also have a corps of organic chemists studying carbon black production problems. It is not to be supposed that these large technical staffs have learned nothing, but it can be safely said that no company has yet developed sufficient knowledge to enable it to predict just what operating conditions must be used at a new plant to enable it to manufacture a black of a quality sufficient to meet the demands of an exacting buyer. In fact, no producer has yet developed sufficient skill to enable him to make first-quality black at all times under varying weather conditions.

The very great utility of carbon black, as compared to its cost, works a hardship on the manufacturer, for no buyer can afford to take risks with the quality of a tire worth $10 in order to save a small percentage on the cost of the carbon black, for which he pays 10 cents at the most.

Although the process of carbon black manufacture is fundamentally simple, the poundage that can be made from a single gas flame is extremely small. In order to turn out a tonnage great enough to be competitive, a plant must contain a very large number of flames, as well as a very large number of collecting surfaces, scraper knives, etc. In the Bowers pool (Texas) plant of the Godfrey L. Cabot, Inc., which is at present the largest in the world, there are 1,140,480 individual flames. The collecting surface consists of 8-inch channel irons weighing 11¼ pounds to the foot. The total channel length is over 90 miles. There is 121 miles of pipe in this plant. It burns 58 million feet of gas and makes over 100,000 pounds of carbon black each day. The factory covers 11.3 acres of ground and consists of 288 burning buildings, each 140 by 14 feet long, serving one common packing house through 12 air separators for grit removal and 24 automatic packers. There is approximately eight miles of screw conveyor necessary to bring the black to the packing house. This plant was wholly constructed by arc welding. There are approximately 205,000 distinct arc welded joints, or over 183,000 feet of arc welded seam. The total weight of steel and iron in the factory is, in round numbers, 10,000,000 pounds. The investment is over $2,000,000.

The only companies that have been consistently successful in the manufacture of carbon black have been those that have specialized. The business has, on the whole, been profitable, but a large part of this profit has been due to the enhancement in the value of gas properties which carbon black companies naturally acquired in conjunction with their manufacturing operations.

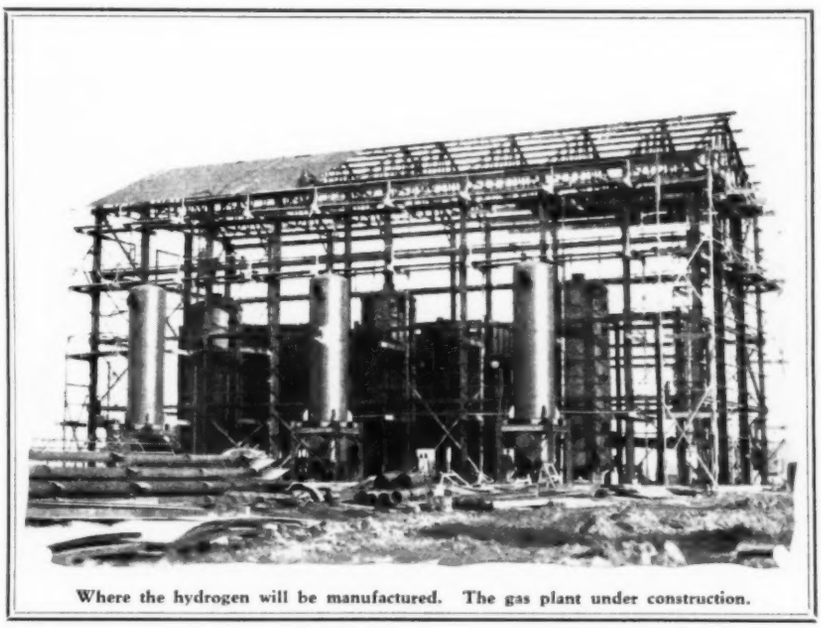
Today approximately three-fourths of the world's carbon black is made from residue gas which would otherwise waste into the air. It seems probable that casinghead gas in oil fields remote from the centers of civilization, before markets for gas can be developed by the construction of pipe lines, will prove the raw material in the future. The gasoline will, of course, be extracted before the gas is burned. When a new oil field with high gas-oil ratio is discovered at a distance from existing gas markets, the natural gasoline manufacturer will be the first gas buyer. Under normal market conditions, the carbon black manufacturer will be a buyer for waste residue gas after the field is sufficiently developed to make a supply fairly well assured.

Recent Developments in Science and Technology of Petroleum

By CARL O. JOHNS, *Standard Oil Development Co.*

THE first systematic investigation of petroleum in the United States was made by Professor Benjamin Silliman, Jr., of Yale College, seventy-five years ago, when some oil from the Cherry Tree deposits in Pennsylvania was sent to him for examination. He made his now classical report on his "rock or petroleum oil" in 1855.

Silliman fractionated the crude oil by distillation and found that chemical changes occurred when the higher boiling fractions are heated and that more volatile constituents are formed from the less volatile oils. He thus discovered a principle which in recent years has led to the development by Burton and his co-workers, as well as others, of the "cracking" process for obtaining gasoline and kerosene from high boiling oils. In refining his distillates, Silliman used sulphuric acid, and this method is still practiced throughout the world. He showed that certain petroleum fractions were useful as illuminants and others as lubricants. At that time whale oil was used for illuminating purposes and sold at $2.50 per gallon and illuminating gas sold in New Haven at $4 per thousand cubic feet. The distillate which Silliman obtained from a sample of Pennsylvania petroleum gave a better light than any other substance which was used for illumination at that time. Silliman heated oil in an iron retort and obtained gaseous hydrocarbons of the "highest illuminating power." He also obtained paraffin wax from his distillation residues and stated that the paraffin could be separated and obtained as a white body from which beautiful candles could be made.



Where the hydrogen will be manufactured. The gas plant under construction.

As a result of distillations, Silliman obtained a yield of over ninety per cent of the whole product, consisting of a series of oils with variable properties which appeared to be valuable for illuminating and lubricating purposes. He also investigated the use of superheated steam as a means of distilling the oil.

The work of Silliman started the petroleum industry with a technical background that has been of great value. With the growth of the production of oil in the United States, other chemists undertook the study of the composition of oil in this country and among these may be mentioned the names of Maybery, Warren and Coates. Chemists in other countries also became interested in petroleum and considerable chemical work was done, particularly in England, Germany and Russia. This early work gave us much of the information which we have today concerning the chemistry of petroleum.

The results of the work of Silliman interested a group of men in the possibilities of petroleum and a small syndicate was formed in New Haven to work the Titusville oil lands. Edwin Laurencine Drake, who has been called the most historic figure in connection with the beginning of the American petroleum industry, was appointed director of the work. The result was the drilling of the Drake well in 1859, which yielded about 25 barrels of oil per day.

Not long after the production of petroleum in Pennsylvania had become an accomplished fact, on a considerable scale, and the value of petroleum was well known, attention was given to the locating of oil in other places. At first no scientific methods of finding petroleum deposits were employed, and these were the days of the man with the divining rod, who professed to be able to locate oil. This stage soon passed and the geologist appeared on the scene and made his study of geological structures that might be favorable to oil deposits and the science of geology became an important tool in oil production. It was not long before geologists were seeking to locate oil in many states and the success which accompanied these scientific studies have resulted in the organization of geological departments in most of the larger oil companies. Today few oil concerns will undertake the risk of drilling without first having sought all the geological data obtainable. The geologist now scours the six continents of the world in quest of oil bearing structures.

The physicist has also appeared more recently on the scene with his torsion balance and his geophysical methods as aids in locating oil, particularly for locatng structures, such as salt domes, where oil may be found. These methods have proven of great value in finding oil.

When plants were established for the refining of oil, it was apparent that the mechanical engineer would be consulted, and as these plants have grown in size and complexity, the mechanical engineering department of every

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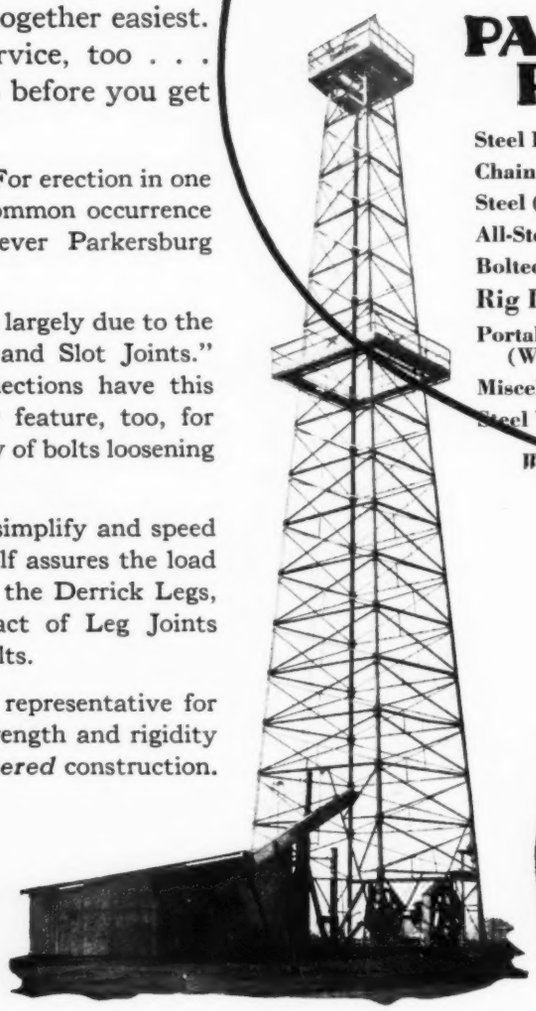

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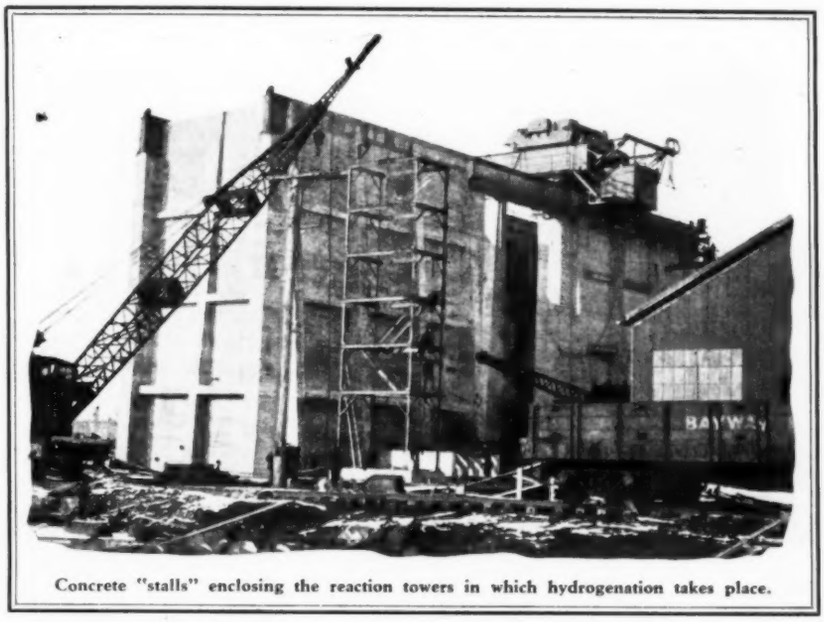
large oil refinery has assumed a very important function in the designing and building of equipment. The necessity of using the best engineering practice in the building of equipment became more important with the introduction of cracking and the pressure still. The first pressure stills operated at about 90 pounds per square inch, and since this pressure was considered relatively high at that time, much greater care and skill had to be exercised in their construction than were needed in building and operating the old type atmospheric stills. The results obtained by using moderate pressures in cracking led to the adoption of increasingly higher pressures, until cracking is now done at 1,000 pounds per square inch. When so high pressures are used the equipment has to be designed and constructed with the greatest engineering skill and fabricated from the most reliable materials.

The science of metallurgy has made great strides within the last decade in the manufacture of alloy steels. The three most important problems are to make alloys that will withstand high temperatures, high pressures and resist corrosion. The researches of the metallurgist have accomplished this to a remarkable degree and the metallurgist has also found his place in the petroleum industry in testing and judging the value of materials. He has advised testing methods which give reliable data concerning the security of equipment. Many petroleum organizations now have well-equipped metallurgical laboratories.

The increase in pressure has not stopped at 1,000 pounds. The new process of cracking and hydrogenating oil, which is now under development in this country and abroad, makes use of pressures ranging from 2,000-3,000 pounds per square inch. This process has more flexibility than any other process heretofore employed, and by the use of suitable catalysts, and varying the operating conditions, it is possible to change very radically the chemical character of the products which are obtained from any feed stock. In other words, this process is not only a method of cracking oil, but it is possible to change the chemical nature of the products contained in the original feed stock, or those which would be formed in the usual cracking processes. By the hydrogenation process it is actually possible to make a barrel of gasoline from a barrel of crude oil.



Concrete "stalls" enclosing the reaction towers in which hydrogenation takes place.

In the Burton cracking process the feed stock is gas oil. This is cracked in large fired drums with a charge of more than 300 barrels per drum. This is, of course, a dangerously large quantity of oil in case of an accident. Now oil is usually heated in fired coils instead of large drums and the cracking may be completed in drums which are not heated as in the "Tube and Tank" process. There is a relatively small quantity of oil in the coils at any one time and this decreases the danger in case a tube gives way.

In the hydrogenation process there is also only a small quantity of oil present in the equipment at any given time and the fire hazard is materially reduced.

Besides those scientists and engineers who work directly in petroleum organizations, there is a large number of technical men engaged in factories which furnish equipment and instruments for the petroleum industry. The day of the rule of thumb-methods has largely passed in petroleum plants. Modern refineries are now using accurate recording instruments, metering equipment and testing apparatus of a highly scientific character. The devising and manufacturing of such equipment demand scientific knowledge and engineering skill, and while the men engaged therein are not directly in the petroleum industry, the success of modern refining methods depends largely on their work. Scientific instruments have become an essential part of all branches of the petroleum industry.

The exchange of scientific and engineering knowledge in the industry is fostered by various societies or divisions of large scientific societies, by publication and by meetings of these organizations. Among these are the American Association of Petroleum Geologists, the Petroleum Section of the American Chemical Society, and the Division of Refining, as well as other divisions, of the American Petroleum Institute, at the meetings of which scientific and technological problems are discussed freely. Such meetings have fostered a spirit of co-operation among the scientists and engineers in the petroleum industry and the increasingly large number of papers presented at the meetings of these organizations is a proof of the willingness of petroleum companies to share the results of their research and experimental work with each other.

The last ten years in the oil industry has been a period of intensive research and development. Many oil companies have built research laboratories and others have increased the size and personnel of those which they previously had. This increase has been due to radical changes in refining methods and an endeavor to improve the quality of refined products, especially the knocking tendency of gasoline. The constantly changing character of the crude petroleum available, due to the opening up of new oil fields, has made much research and experimental work necessary and the number of technical men employed in the oil industry in the United States is today many times that of ten years ago.

Petroleum is the greatest existing source of hydrocarbons. The three principal classes of hydrocarbons are aliphatic, aromatic and hydro-aromatic or naphthenic compounds. All of these three classes are widely represented by a large number of different compounds in the various types of petroleum. It is impossible to estimate how many different hydrocarbons are found in petroleum, but it is well known that the number

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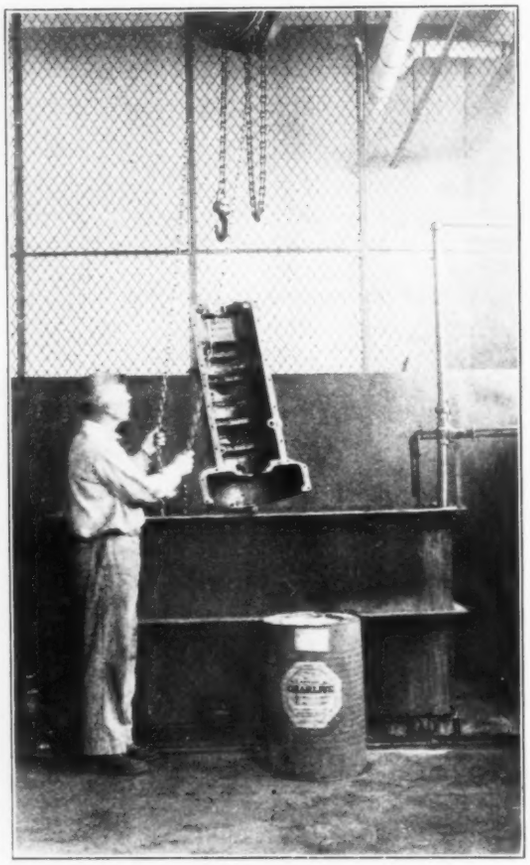

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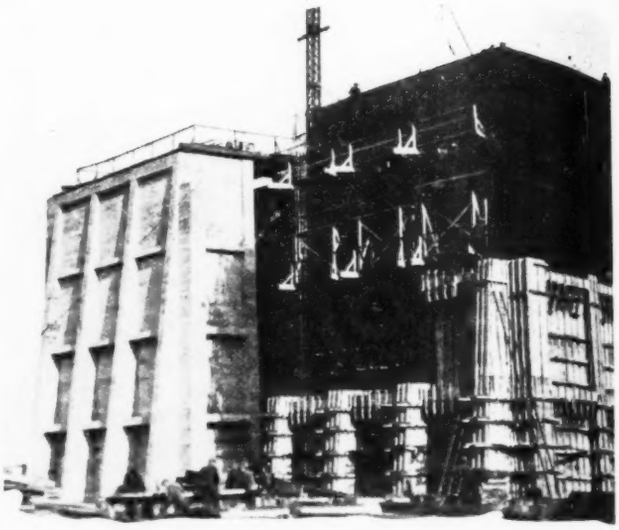

A view of the "stalls" prior to completion, showing the network of reinforcing.

is very great, and that so many compounds occur in any one petroleum that it is extremely difficult to separate them. It is for this reason that petroleum has been used so little in the past as a source of raw materials for manufacturing chemical compounds. However, the great improvement which has been made in fractionating equipment and fractionating methods enables us to separate the compounds in the simpler petroleum fractions, and further improvement will bring us within striking distance of the separation of compounds from more complicated petroleum mixtures.

During the last decade the attention of chemists has been turned to petroleum as a source of raw material from which chemicals can be manufactured. During the great war the British obtained large supplies of toluene from oil from their eastern possessions and from it made trinitrotoluene or "T.N.T."

Two commercial methods have been developed for the manufacture of alcohols from petroleum hydrocarbons. One of these methods uses the unsaturated gases which are formed during the cracking of petroleum. These gases are absorbed by sulphuric acid and the compounds formed by the combination of the unsaturated hydrocarbons and the sulphuric acid are afterward treated with water, which results in the formation of a series of alcohols and the recovery of the sulphuric acid. The alcohols made by this method are isopropyl, secondary butyl and secondary amyl alcohol, together with a small quantity of still higher alcohols. These acohols are used for a variety of purposes, but their chief use is in the manufacture of lacquer solvents. The second method of manufacturing alcohols from petroleum consists in the chlorination of natural gas, and the subsequent treatment of the chlorinated compounds with a water solution of caustic soda under pressure. This method also gives a series of alcohols, differing from those obtained by the first method. These alcohols are valuable for the manufacture of chemical compounds and lacquer solvents.

Marco Polo, the famous Venetian traveler, writing about Baku petroleum at the end of the thirteenth century, states that the oil is found in great abundance, but is not good to use with food, but is good to burn and is also used to anoint camels that have the mange. However, the chemist has been able to convert petroleum ipto compounds which are fit for human food. Fatty acids are now made on a commercial scale from petroleum wax. By combining these fatty acids with glycerine, fats are obtained of the same kind as those from animals. While it is not practical to do so, it is theoretically possible to make sugars from petroleum by

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chemical synthesis. Fats and sugars supply us with two of the three most important classes of foods, which are fats, proteins and carbohydrates. Sugars are carbohydrates.

There is now great activity in this country in studying the composition of petroleum in the laboratories of oil companies, the United States Government and universities. During the last four years petroleum research has been stimulated and aided by two funds of $250,000 each, contributed by Mr. John D. Rockefeller and the Universal Oil Products Company. The distribution of these funds is made by committees of the American Petroleum Institute. The projects are of a fundamental character and deal with many phases of the petroleum industry, and are conducted by a large staff of eminent chemists, physicists, geologists and engineers. The directors of these projects are giving their time freely in supervising the men who are carrying on the researches which are supported by the two funds.

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NO lost time, stop or delay of work was made when the Indian Territory Illuminating Oil Company moved one of its warehouses. During the entire time of moving, lights, gas and phone services were maintained and trucks continued to be loaded out from the docks.

Lights and phone service were kept intact through the use of extra lengths of wire that were let out as the moving progressed. Gas service was aided by a rubber extension.

From time to time it was necessary to make new connections along the way.

The building was moved with about 200 tons of material in stock and without removing any of it from the shelves. None of the stock was displaced, and not a window broken despite the fact that two ditches were crossed while moving the building approximately one mile. The building itself is 90 x 50 feet and about the height of a two-story house.

A total of 52 days were required to jack the warehouse up, move it and set it on the new location. The building is now located on the Goforth farm in the Bowlegs pool of Greater Seminole.

R. C. Roberts, Tulsa, was moving contractor, and did the job with rollers, a cat-stand, and one team.

Gas Engineers and Chemists Met at Cleveland

ENGINEERS and chemists from all parts of the United States and Canada attended the fourth Joint Production and Chemical Conference, held under the auspices of the Carbonization, Water-Gas and Chemical Committees, Technical Section, American Gas Association, at the Cleveland Hotel, Cleveland, Ohio, May 21-23.

At American Gas Association Headquarters, New York, it is learned that the committees which contributed to the conference produced a program of unusual interest to this branch of the gas industry.

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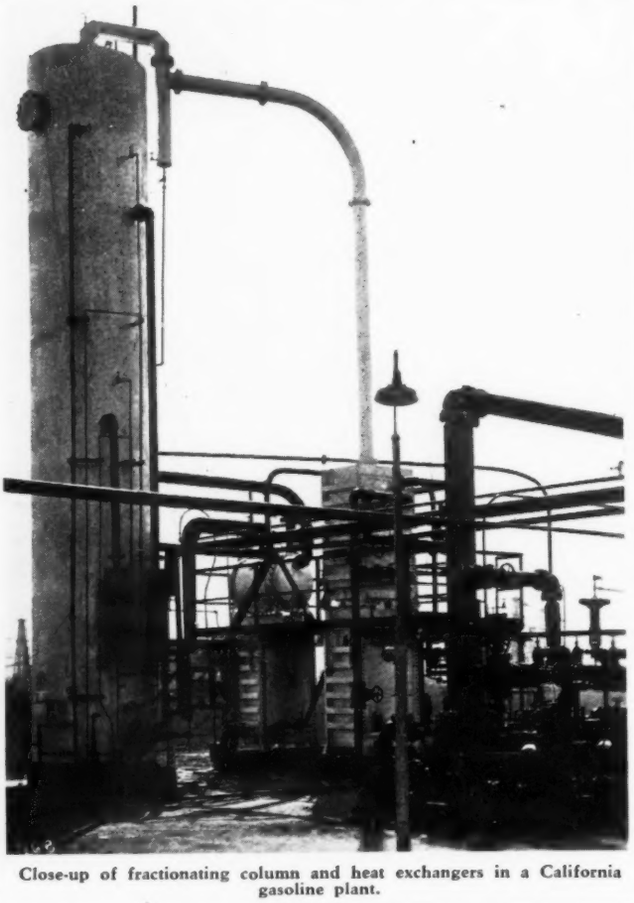
Reheating in Still Results in

Gasoline Plant Economy

By F. L. KALLAM, *M. E.* [1]

THERE has been some comment within the industry regarding the desirability of using heating sections in connection with absorption plant stills. Much of this discussion results from initial failure to understand the true function of the heaters, while in a number of instances data obtained from field tests have only added confusion to the picture. Then, again, there is always that resistance to the adoption of new types of equipment which is due to unfounded prejudice. Neglecting the present influence due to prejudice and the discrepancies in test results, failure to universally accept the use of reheaters must be charged to the lack of application of the laws of fractionation. Efficient stripping of the gasoline fractions from an oil depends upon the gasoline component of the mixture having a relatively high vapor pressure under the distilling conditions. This follows directly from the well-known and accepted theory of fractionation, and points out the need of maintaining the stripping column at a maximum temperature.

Numerous tests made during the past year upon absorption plant stills equipped with heaters have not in the majority of cases proved favorable to this type of apparatus. In spite of this condition, however, there has been some hesitancy on the part of the industry at large to condemn the use of such heaters. This is fortunate, since quite recently there has been reported results of a test upon a commercial unit operated with and without a heater under identical conditions. This makes comparison of the two methods practical. This comparative test was made upon a conventional sixteen-plate absorption plant still in which the hot enriched oil from the preheater was introduced upon the eighth plate. The still heater was of the external type, so arranged that the heating surface could be readily placed out of service without disrupting the operation of the distillation unit. The heated oil from the heater passed over two plates before leaving the bottom of the still. Steam for reduction purposes was introduced into the still directly beneath the bottom plate.



Close-up of fractionating column and heat exchangers in a California gasoline plant.

The total test was of 12 hours duration, the first half of this period being devoted to operation without the use of the heater and the second half of the period to operation employing the heater. Great care was exercised that the absorption pressure, gas rate, and oil to gas ratio were identical for both parts of the test, and as a result the temperature of the rich oil leaving the absorbers to the distillation unit was the same for both test periods. Likewise, the distillation unit for both tests was operated in an identical manner, using the same pressure for distillation and condensing as well as the same quantity of steam for reducing the boiling points of the gasoline fractions. The reflux to the still for both tests was maintained such that the vapor temperature to the condenser was identical. Further, by controlling the quantity of steam to the oil preheater, it was possible to secure the same temperature of inlet oil to the still for both tests.

It is now apparent that with these constant conditions the only variable during the tests was the temperature of the lean oil leaving the still, which in Test 1, without reheating, was 9 degrees lower than the inlet oil temperature. In Test 2, however, using the heater, the stripped lean oil left the still 4 degrees warmer than its entering temperature. Under these conditions any difference in production or quality of the stripped oil from the two tests must be attributed to the one variable of the test —the temperature of the oil in the base of the still. In this connection it is necessary to note that the fall in temperature of the oil from the feed plate to the third plate from the bottom, where it enters the reheater, is identical in both tests. The only difference in temperature, therefore, within the still for the two tests is in Test 2 where the heater was in service, which resulted in warmer oil on the bottom two plates.

In the table on the following page will be found a resume of the test data obtained.

A close perusal of the following data will reveal many interesting features, among them being the fact that the use of the reheater resulted in a much more completely stripped oil than where the heater was not used. Even disregarding the oil saturation tests, the advantage still remains with the

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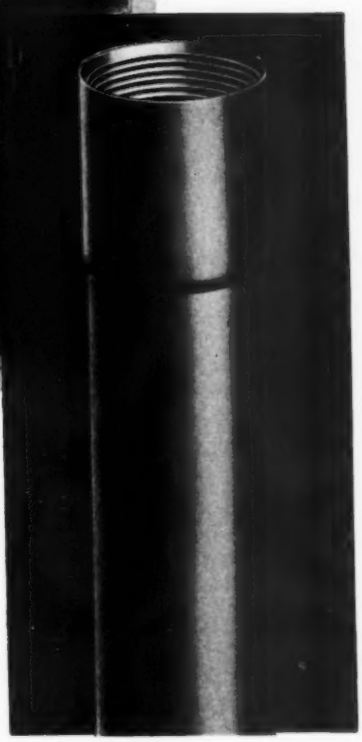

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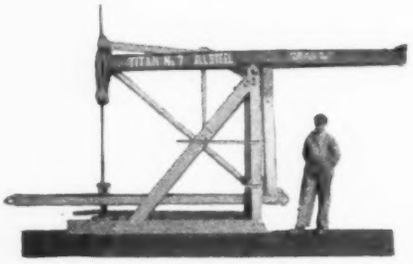

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use of the heater since the stripped oil for this condition has the lower vapor pressure. As the more completely stripped lean oil was obtained at no greater expenditure of reducing steam, it can rightly be concluded that this advantage is gained by reason of the higher temperature prevailing upon the two lower plates of the still.

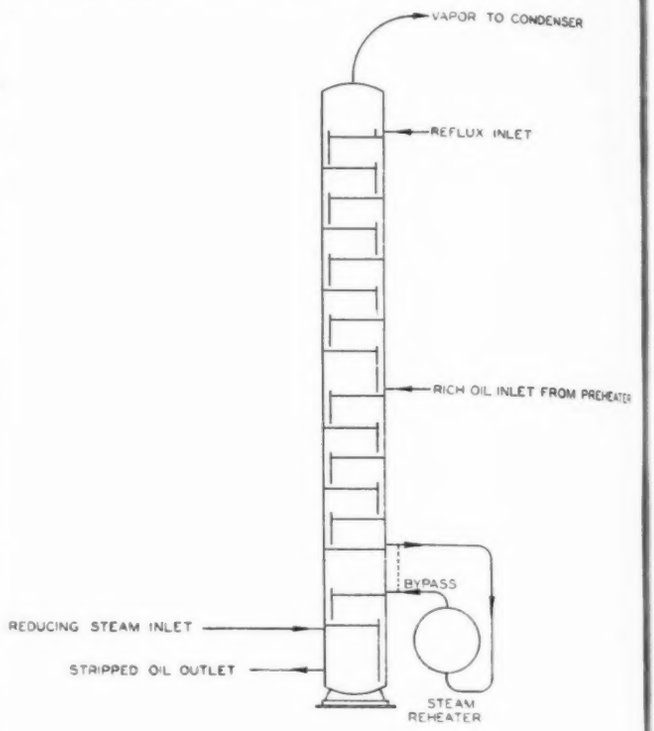

FIGURE No.1.- FRACTIONATING COLUMN

The fact that the use of the reheater results in a so-called "leaner" oil reflects itself also in a corresponding greater gasoline production. This increase is of the order of 16.8

TABLE No. 1

ITEM		
(1) Test number	1	2
(2) Reheater	Not used	Used
(3) Oil rate from still, gal./day	408,300	408,300
(4) Temperature oil to still, Plate 8, deg. F.	302	302
(5) Temperature vapor to condenser, deg. F.	215	215
(6) Temperature reflux to still, deg. F.	80	80
(7) Temp. oil to reheater, Plate No. 14 deg. F.	294	296
(8) Temp. stripped oil leaving still, deg. F.	293	306
(9) Pressure on still, lbs. sq. in. ga.	20	20
(10) Gasoline produced, gal./day	18,300	22,000
(11) Uncondensed gasoline vapor cu. ft./gal. gasoline produced	7.4	6.7
(12) Reducing steam—		
lbs./day lean oil circulated	0.0491	0.0491
lbs./gal. lean oil circulated	0.349	0.349
(13) Steam used for reducing preheating and reheating, lbs./hr.	12,190	12,360
(14) Steam used for reducing, % of total	48.7	48.1
(15) Steam used in preheater, % of total	41.8	51.3
(16) Steam used in reheater, % of total	0.0	10.1
(17) Saturation of stripped oil @ 300 deg F.	1.3	0.5
(18) Saturation of rich oil @ 300 deg. F.	5.8	5.0
(19) Specific gravity of stripped oil, deg. A. P. I. @ 60	34.7	34.6
(20) Specific gravity of rich oil, deg. A. P. I. @ 60	36.5	36.2
(21) Specific gravity of gasoline, deg. A. P. I. @ 60	73.7	73.0
(22) Initial Engler boiling point of gasoline, deg. F.	67	68
(23) End-point of gasoline, deg. F.	363	369
(24) Engler recovery of gasoline, %	92.3	92.0
(25) Vapor pressure of lean oil—		
@ 100 deg. F. mm. abs.	17.5	13.0
@ 296 deg. F. mm. abs.	80.0	61.5

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per cent greater than produced without the reheater, which at first thought appears surprisingly high. However, the lean oil obtained without the reheater in service contains a much greater quantity of heavy gasoline fractions, a fact further borne out by the higher gravity of the gasoline production. Also, the final boiling point of this gasoline is lower than in the case of the gasoline produced with the reheater in service. The fact that the Engler distillation recovery is not greater in the case of Test 2, using the reboiler, is undoubtedly due to this gasoline containing more light volatile fractions which lower the Engler condenser efficiency. This is indicated by the initial boiling points of the gasolines as well as the vapor pressures of the two oils themselves.

Further, considerable more vapor remained uncondensed per gallon of gasoline produced for the case of not using the reheater than where it was used. This was to be expected since the vapors going to the condenser contained a somewhat lower percentage of the heavier gasoline fractions, and with constant condensing pressure, the condensing efficiency for this fraction would be lowered. For the case of using the reheater the reverse is true, the efficiency in condensing the heavier fractions being relatively greater than for the lighter fractions. The net over all condensing effect, as shown by the lesser amount of uncondensed vapor, is materially greater for the case in which the still is operated with the reheater.

As has been mentioned before, the steam for reducing purposes in the still was identical for the two tests, being 0.0491 pounds per pound of lean oil processed. Notice, however, that had only enough steam been used for the case in which the reheater was employed to strip the oil to the same degree as that obtained without the heater, the steam economy would have been considerable. On looking at it from the standpoint of operation without the heater, it would have been necessary to greatly increase the steam rate had the lean oil vapor pressure and saturation been reduced to that obtained when using the heater. In either event, stripping the oil to the same degree would result in marked reducing-steam economy in favor of the use of the reheater.

Turning now to a consideration of the total steam used by the distillation unit, we find that for the test conditions using the reheater 12,360 pounds per hour were required. Without the reheater, and producing 16.8 per cent less gasoline, the steam used was 12,190 pounds per hour. Of these amounts, 5,940 pounds were used for reducing purposes in each case, leaving 6,250 pounds for the preheater in Test 1 where the reheater was not utilized. In the case where the heater was used, the latter consumed 1,250 pounds per hour while the preheater figure was 5,170 pounds. The summation of these two figures gives 6,420 pounds per hour which compares quite favorably with the 6,250 pounds used in the preheater alone in Test 1. It is evident therefore that the steam required by the preheater and reheater on the one hand was no more than that required by the preheater alone on the other, this comparison being made for the same temperature of inlet oil to the still.

From these data it may therefore be concluded that for the same oil temperature to an absorption plant still the use of a reheater is conducive to the greatest steam economy for any degree of stripping of the lean oil. This economy occurs not only in the still itself, but also in the condensing end of the distillation unit where less agitation steam will be condensed along with the gasoline fractions. When considered from an economic standpoint, the use of a reheater results in a higher over all plant efficiency than would otherwise be obtained without the use of a heater.

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Growing Importance *of* Natural Gas

By

W. R. KUBISTA, *Engineer, Central States Power & Light Co.*

IT is with not a little justification that we of the natural gas industry should brag about its astounding progress. Natural gas has facetiously been called the answer to a financier's prayer. Those things which several years ago would have been considered wild dreams are today looked upon as ordinary feats in gas engineering. As an illustration consider the recently constructed and projected pipe lines:

A four-hundred-thirty-mile line from Louisiana to St. Louis.

A one-hundred-seventy-five-mile line from Montana to Rapid City, South Dakota.

A four-hundred-mile line from Texas to Wichita and Kansas City.

A two-hundred-ninety-mile line from Wyoming to Salt Lake City and Ogden, Utah.

A two-hundred-eighty-mile line in California to San Francisco and Oakland.

A two-hundred-eighteen-mile line from New Mexico to El Paso.

A two-hundred-ten-mile line from Louisiana to Memphis, Tennessee.

A one-hundred-seventy-five-mile line from West Virginia to Louisville, Kentucky.

A one-hundred-eleven-mile line from Sunburst Field, Montana, to Great Falls, Montana.

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The immensity and rapid growth of the natural gas industry can best be realized from consumption figures. In 1928 the consumption was more than 1,567,000,000,000 cubic feet, and in 1929 more than 1,725,000,000,000 cubic feet, or enough to replace approximately 85,000,000 tons of bituminous coal. It is claimed that nearly 80 per cent of the total natural gas sold is used by the industries.

Chambers of Commerce recognize natural gas as a civic asset and advertise it as one of their valued possessions.

Cutting a 28-inch trench for an Oklahoma line.

Production

Changes in the relative importance of the sources of fuel and power are reflected in an analysis of world energy production for the fifteen-year period 1913-1928, made by the National Industrial Conference Board.

The analysis shows that while the production of crude oil and hydroelectric power have during this period increased by 243 and 162 per cent respectively and that of natural gas by 133 per cent, the world output of coal has increased only 5 per cent.

A survey on this same order made a year or two from now will doubtless disclose even a greater change, particularly with respect to the United States. Natural gas is now displacing coal in many areas.

In connection with the production of natural gas it is interesting to note, briefly, some of the developments and problems in the field.

Recent work down in the Louisiana fields has shown that large wells can be tubed under high pressure with only a comparatively small loss of gas. The whole job is accomplished in a short time by a system of control heads and snubbers. Obviously, this system should afford large savings and lengthen the life of each well.

It is also rather gratifying to note with what skill and success most of the extremely high pressure wells in the Oklahoma City field have been handled. One outstanding development is the use of three regulators to reduce pressure into the lines. Such extreme pressures as are found in this field make this necessary in order to avoid serious freezing of lines.

There has recently been considerable effort put forth in the matter of storing gas in abandoned dry gas sands. Up to the present time the idea has met with moderate success where the conditions have been just right. As an illustration, the company with which the author is associated, in one instance, began with a total storage of about 1,400,000 metered cubic feet and over a period of thirteen months withdrew 600,000 metered cubic feet. The original pressure was 200 pounds per square inch, and after thirteen months of periodical withdrawal the pressure dropped to seventy pounds per square inch. It is felt that by exercising care a good portion of the remaining gas may still be recovered.

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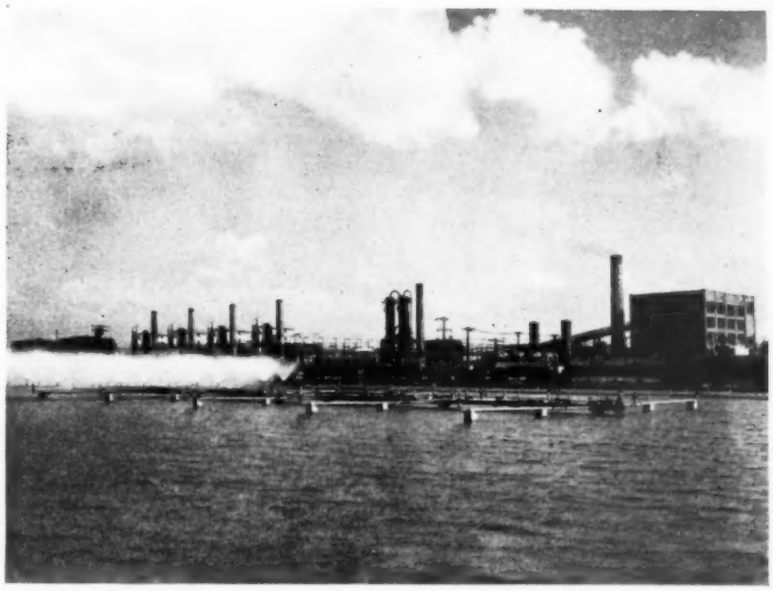

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most notable developments in the construction of large gas transmission lines is the use of pipe ranging from 30 to 40 feet per joint instead of the former 20 to 22-foot lengths. New pipe manufacturing methods have made possible this longer pipe with the result that welding costs have been very materially reduced. New methods are also producing lighter pipe with strength equal to that of the heavier pipe formerly in common use. There can be little doubt that these developments have played their part in animating the recent activities in long distance pipe line construction.

The extremely high cost of large lines and the absolute dependence of cities and industries on these lines for fuel supply has resulted in the careful consideration of protection against corrosion. Before any major line is begun a careful survey of soil conditions is made and the proper protection chosen for each particular condition. The less expensive cold applications are used where corrosion is not likely to be severe, but where bad conditions are encountered line builders resort to hot enamels and sometimes wrapping. Efficient machines are being used to facilitate the coating of large diameter pipe.

Distribution

The distribution of natural gas in cities where manufactured gas was formerly used has developed interesting problems, most of which were solved with little difficulty. Most notable of these problems is the spraying of gas with oil and steam before it enters the distribution system, so as to produce a condition similar to that which existed with manufactured gas. In one of the first conversions it was found that natural gas absorbed the moisture and oils from the caulking material in the joints of cast iron pipe, subsequently causing excessive leakage and line loss. Automatic spray machinery has solved the problem.

A recent achievement in the distribution of natural gas is the use of an odorizing compound for the purpose of giving the gas a noticeable odor. Leaks will be more readily detected and the danger from asphyxiation will be lessened. The requirements are that the compound shall have a penetrating but not nauseating odor, that it shall not condense, corrode or in any serious way affect the pipes and meters. An oil for this purpose has been developed by the Standard Oil Company of California. Two gallons per million cubic feet of gas atomized into the system will suffice to give the desired results. As the saying goes, "The nose knows," and it will worry consumers into keeping their house piping and service lines in repair.

Liquefied Petroleum Gas

With the advent of liquefied petroleum gas as a salable by-product of refineries and the natural gas industry much thought has been given to the subject of disposal and how the product will effect gas utilities in general.

Prominent men in the gas industry believe that this product will prove to be more of an asset to gas utilities than a liability. Their reasoning has it that in dealing directly with the consumers the original producers have no great advantage, but that in having a limited number of large outlets in the form of utility companies under contract, business conditions would be more uniform and convenient.

Doubtless, the American Gas Association, which is studying the problem at this time, will evolve some means of handling the product to the mutual benefit of the utilities and refineries.

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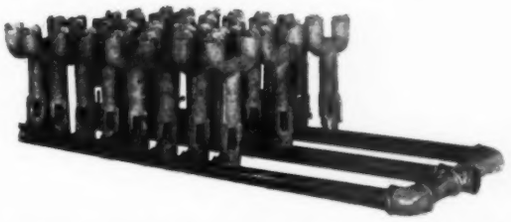

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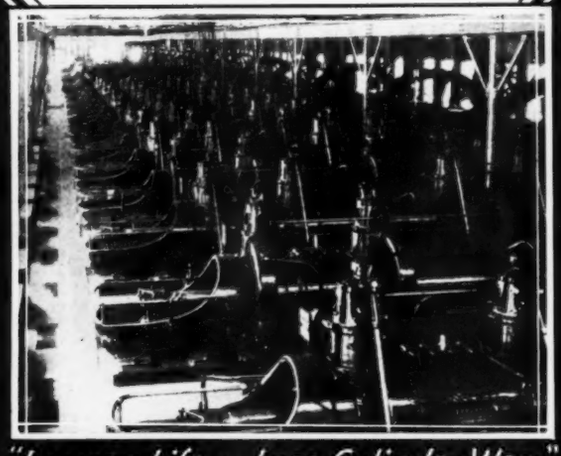

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SAFETY FIRST *in* REFINERY WORK

By H. L. SMITH,
Asst. Supt., The Pure Oil Company

IN this era of rapid advancement, in which the oil industry is one of the leaders, it is absolutely necessary that a well-organized safety organization be maintained at all times in order that the idea of safety be presented to each and every employe constantly. In order to do this every leader in an organization must be thoroughly sold on the safety idea so that they can carry the safety slogan to each one of their men.

The Muskogee Refinery of The Pure Oil Company has for years been developing just such an organization and I believe that the method employed by us would be a help to every refinery man in the country.

First, we have an organized committee composed of twenty-two of the key men throughout the plant, which group meets in the superintendent's office every Friday morning at eleven o'clock. At this time every man is given the opportunity to suggest ways and means of making his department or the other fellow's department safer and more efficient. These meetings last from one hour to one hour and a half and give every one a chance to understand each and every one of their fellow foremen and in this way can create a harmony that goes a long way toward preventing accidents.

The next step towards accident prevention is a monthly dinner and talk given on the third Monday night of each month at the Country Club. At this meeting, composed of the same groups mentioned above, we have each foreman

Scene in a Russian refinery.

take a night and go through the entire operation of his department. The speaker is expected to be able to answer all questions pertaining to his department that might arise from his talk and by the end of the meeting every man present is familiar with the speaker's department. It is the idea of the management that the more each man knows about the other fellow's work the safer it is for everyone in the plant.

In order that every employe gets the opportunity to receive equal benefits from such talks as mentioned above, we are holding weekly classes at night for all employes, and at these meetings every department is thoroughly explained by means of blackboard talks and questions.

Of course it is very necessary that a first-class first aid department be maintained at all times to insure prompt treatment for all small injuries in order that infections and

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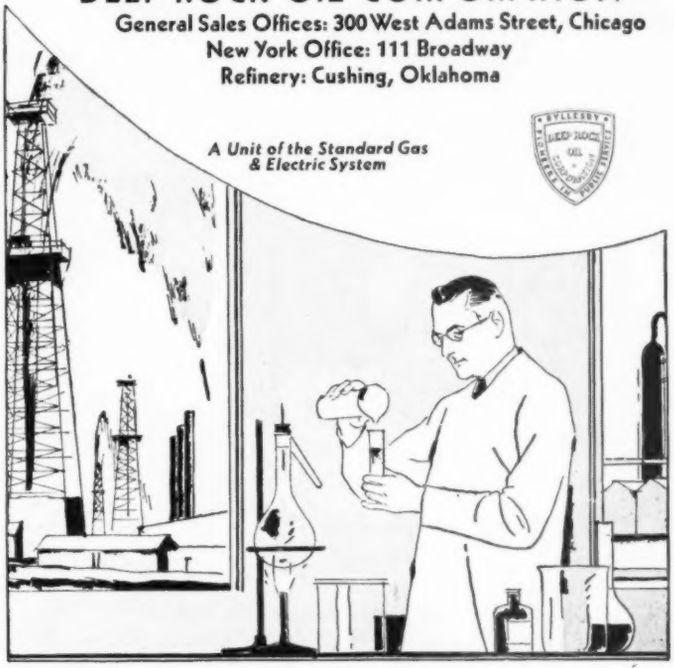

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REORGANIZATION OF OKLAHOMA CONTRACTING CO.

The Oklahoma Contracting Company, which has been identified with pipe line activities throughout the Mid-Continent and Southern fields for the past twelve years, has been reorganized and expanded, according to Tom Jones, president of the company. Mr. Jones announced four new associates, all of whom are well known and have been actively identified with the oil industries for the past twenty years. They are Ray Johns, C. A. Mulligan, Bill Hanrahan and Mike Deluca. Incidentally, Tom Jones and his four associates are the same age, thirty-nine years old.

Ray Johns has been with the Oklahoma Contracting Company for the past four years, in the capacity of consulting engineer and general superintendent. C. A., better known as "Mugs", Mulligan comes to this company from the Humble Pipe Line Company, where he was assistant general superintendent in charge of construction and pumping stations. With Mr. Johns, he will have supervision of construction work in the field.

Bill Hanrahan has been in the pipe line and oil business for twenty-four years, serving in various capacities in the field. He is a brother-in-law to the late H. A. Gump, who was associated with the Oklahoma Contracting Company until his death one year ago. Mr. Hanrahan will be in charge of the office in Dallas.

Mike Deluca, who has had twenty years' experience in the field, will continue in charge of construction work.

The Oklahoma Contracting Company was organized in 1918, and incorporated in 1923. During the twelve years it has been in existence, this firm has constructed more than 5,000 miles of pipe lines for many of the major oil and gas companies throughout the South and Middle-West. Offices are in Dallas, Texas, and Tulsa, Okla.

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Analyzing Compressor Indicator Cards

By A. L. BRADFORD *and* J. J. KING, *Magnolia Gas Co.*

TO assist station engineers in analyzing compressor indicator cards by the use of adiabatic and isothermal compression lines drawn on the indicator card to determine causes of compressor inefficiencies and to help correct them, the following procedure was planned. It was found to assist greatly in the work, which was done more painstakingly and efficiently.

In the compression of a gas there are two limiting conditions between which the compression may take place. One limiting condition is compression in such a manner that all the heat resulting from the compressive action remains in the gas and none is lost to cylinder jacket water or passes from the cylinder walls to the surrounding air. This limiting condition is called adiabatic compression, and is the least efficient method possible in the compression of a gas. The other limiting condition is compression so that all the heat resulting from the compression is taken away by either the cylinder jacket water or lost to the air or through the two combined channels. In this case the temperature of the gas leaving the cylinder is the same as that of the gas entering. This limiting condition is termed isothermal compression, and is the most efficient method possible in compressing a gas. Somewhere between the two limiting conditions will be found the actual compression line as given by an indicator card if the compressor is in good condition.

Obviously, in practice neither of these limiting conditions will be reached. Some of the heat developed during compression will be carried away by radiation and by jacket water, but not all of it. It is evident, also, that an actual compression line is desired that will approach as nearly as possible the isothermal line, for isothermal compression makes possible the pumping of a given volume or weight of gas with the least horse power expended. So in practice, the path of the compression line will fall between the adiabatic and isothermal lines—provided there is no extreme case of leaking rings, breaking valves, etc. The actual compression line will approach the adiabatic or isothermal line —depending upon the efficiency of the compressor, and the compressor efficiency in turn is determined by cylinder clearance and effectiveness of jacket water in removing heat from the gas. It is obvious, then, that the cylinder with small clearance and having a very effective heat removing system will give a card with a compression line more nearly approaching the isothermal. It should always be remembered that valve and piston ring trouble affect the actual compression line, and in some cases may alter it to such an extent that apparently there is no relation between it and the limiting lines.

In Figure 1 we have an actual compressor card upon which have been drawn the adiabatic and isothermal lines. The position of the actual compression line relative to the two limiting lines indicates fairly good conditions in the cylinder, and is about as should be expected from a cylinder in "average" condition. Any serious defects in the operation of valves or rings may cause the actual compression line to approach either the adiabatic or isothermal or even cross one or both of them, and herein is the advantage of drawing in the limiting lines. These lines make it possible to locate defects that probably could not otherwise be discovered without going into the compressor cylinder.

Except in extreme cases of defects in the operation of valves, rings, etc., it is almost impossible to locate definitely the trouble by studying the card without the aid of some reference point or line. To facilitate the analysis of compressor cards, it is possible to draw in the limiting lines with but very little time and effort expended. To determine these lines by starting out with the standard formulae for adiabatic and isothermal compressions might prove somewhat difficult for those not familiar with the physical laws pertaining to gases, but the entire procedure has been considerably simplified by the introduction of constants and by all calculations being reduced to plain multiplication and division.

The following simplified procedure can be used for determining the adiabatic and isothermal lines on any specific compressor card:

Determine the length of the indicator card by drawing in the lines MN and OP perpendicular to the atmospheric pressure line as shown in figure B. The card length is then divided into ten equal parts and perpendiculars drawn as indicated by the lines at A, B, C, etc. The absolute zero pressure line is located by laying off a line below the atmospheric pressure line at a distance, according to the scale of

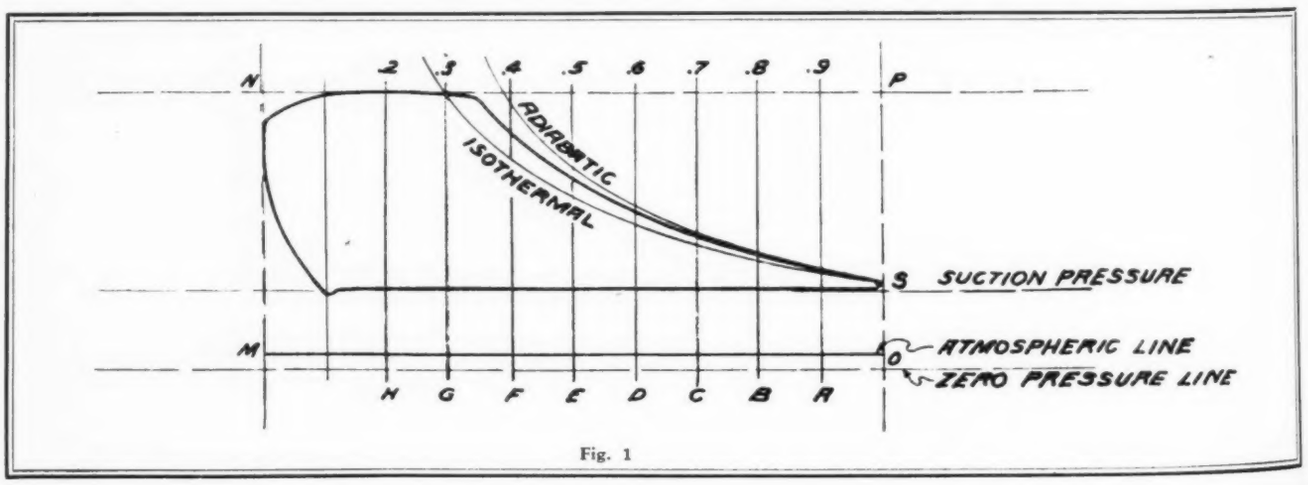

Fig. 1

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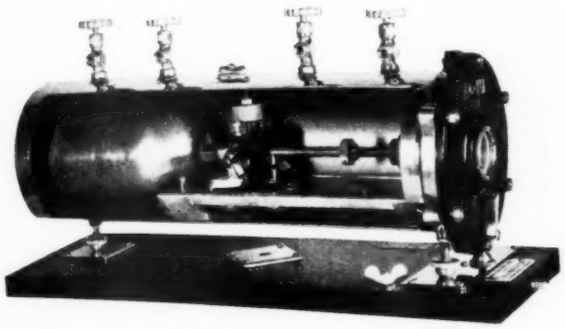

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the spring used with the card, equal to about 14.5 pounds pressure, which value is sufficiently accurate for ordinary calculations. The scale of the card refers to the calibration of the indicator spring. If a 160-pound spring is used, then one inch measured vertically on the indicator card is equal to 160 pounds. If a 240-pound spring is used, then one inch measured vertically on the card is equal to 240 pounds pressure. It is convenient to have a graduated rule or measuring stock calibrated according to the scale of the indicator spring—otherwise the task of laying off the pressures will prove somewhat difficult.

See figure 2 for method of dividing card into ten equal parts.

Since the vertical distance on the indicator card represents pressure within the cylinder, the horizontal distance represents volume. As the distance traversed by the piston has been divided into ten equal parts, the volume of gas ahead of the piston at any specific point such as C, measured on the basis of a total cylinder capacity equal to 1, is 0.7. In a similar manner, the point F represents a value of 0.4 for the volume ahead of the piston. It should be remembered that these values for volume are the same irrespective of the pressure within the cylinder, that is, they represent absolute volume. Using these assumptions relative to cylinder volume and neglecting clearance, we can now develop the isothermal and adiabatic formulae and show their application to compressor cards.

Isothermal Compression

The relations between pressure and volume in the isothermal compression is represented by the equation

$$P_1V_1 = P_2V_2$$

$$\text{Then, } P_2 = \frac{P_1V_1}{V_2}$$

Where V_1 = Volume of gas in cylinder in cubic feet at beginning of compression. (This volume is the total volume in the cylinder ahead of the piston during compression, and will be 1 according to assumption.)

P_1 = Absolute pressure in pounds per square inch at the beginning of compression. (Absolute pressure is gauge pressure plus atmospheric pressure, or gauge pressure plus 14.5 pounds—approximately.)

V_2 = Volume of gas in cylinder in cubic feet at one end of compression. (This volume determined by the point selected such as A, C, E, etc.)

P_2 = Absolute pressure in pounds per square inch at end of compression. (This pressure corresponds to the volume V_2.)

In any calculation the value of P_1, designated by the point S in Figure 1, can be taken from the card; V_1 will always be 1—using the scheme we have selected; V_2 is determined by the particular point selected for calculation; therefore, P_2 is the only unknown quantity.

Example

Taking point "E" in Figure 1, we have:

$$V_1 = 1;\ V_2 = 0.5;\ \text{and } P_1 = 114.5$$

$$\text{Therefore, } P_2 = \frac{114.5}{0.5} = 229 \text{ pounds per square inch absolute.}$$

Measuring vertically from the zero pressure line at the point "E" the scale distance equal to 229 pounds, we determine one of the points on the isothermal line. The other points are found in exactly the same manner.

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Adiabatic Compression

The relation between pressure and volume in the adiabatic compression is represented by the equation $\frac{P_2}{P_1} = \left\{\frac{V_1}{V_2}\right\}^n$, in which the value of "n" is the ratio of the specific heats of the gas, and for convenience and ease in calculation will be taken as 1.26. Then, $\frac{P_2}{P_1} = \left\{\frac{V_1}{V_2}\right\}^{1.26}$ or, $P_2 = P_1 \left\{\frac{V_1}{V_2}\right\}^{1.26}$.

As in the determination of the isothermal line, all the values are known except "P_2," and a factor, involving $\left\{\frac{V_1}{V_2}\right\}^{1.26}$, can be derived for any given value of "V_2," thus leaving only one operation in arriving at the value of "P_2," this being the multiplication of "P_1" by the factor. It will be observed that the use of the factors simplifies the procedure considerably, saving both time and labor in making the calculations. The following table of factors is sufficiently complete for any indicator card that will be encountered:

Values of V_2	Factor	Values of V_2	Factor
0.9	1.140	0.5	2.394
0.8	1.325	0.4	3.177
0.7	1.568	0.3	4.550
0.6	1.904	0.2	7.600

Example

Taking the point "E" again in Figure B, we have $V_1 = 1$; $V_2 = 0.5$; and $P_1 = 114.5$. From table, factor 2.394. Therefore, $P_2 = 114.5$ times $2.394 - 275$ pounds per square inch absolute.

Measuring vertically from the zero pressure line at the point "E," the scale distance equal to 275 pounds, we determine one of the points on the adiabatic line. The other points are determined in a similar manner. Having determined enough points to draw in the two curves, the paths are brought out by joining the points with a smooth curve.

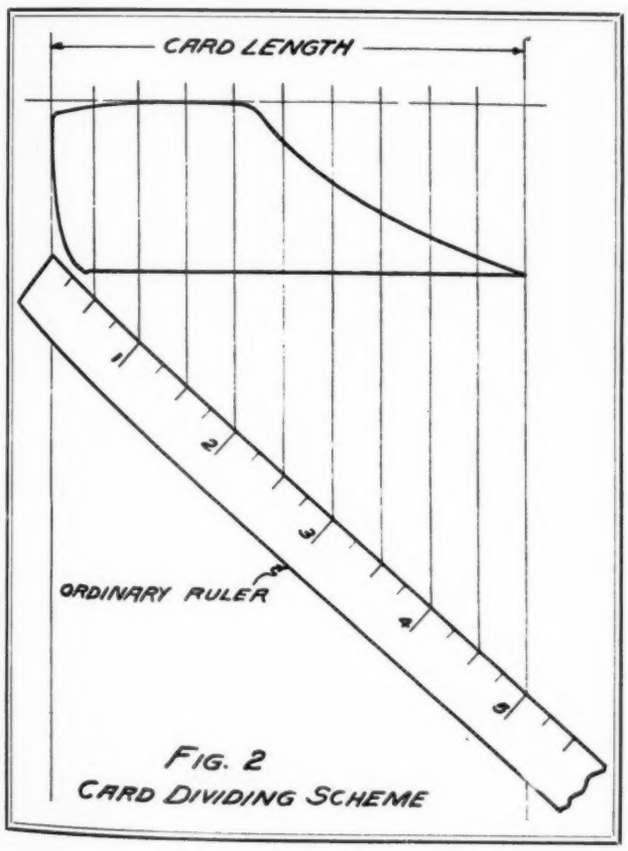

FIG. 2
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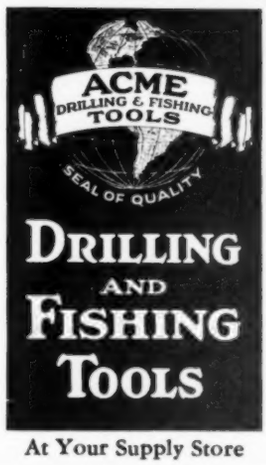

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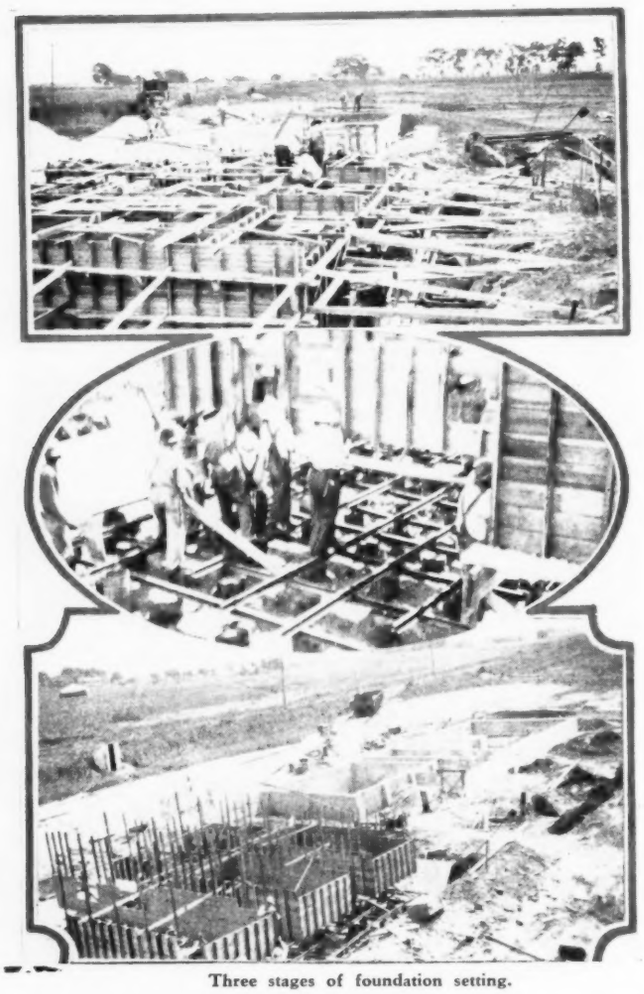
« « « « PRINCIPLES AFFECTING DESIGN

By C. S. WORLEY, *Chief Engineer,*

IT is seldom that the designing engineer is required to give any great amount of consideration to gas engine foundations as the drawings and specifications furnished by the manufacturers are deemed adequate for all but the more unusual conditions. These specifications are based on the general assumption that the bearing strength of the soil is normal, or that it has a minimum supporting strength of four thousand pounds per square foot. In localities where the soil strength is less than two tons per square foot, additional footings are required, especially where horizontal type engines are installed.



Three stages of foundation setting.

The depth and weight of a gas engine foundation are largely governed by the strength of the soil. In normal soil the depth of the foundation, measuring from the floor, should be from five to six times the cylinder bore for large and medium sized gas engines of horizontal type. The other dimensions may be calculated to give the necessary weight, and proper distribution of that weight.

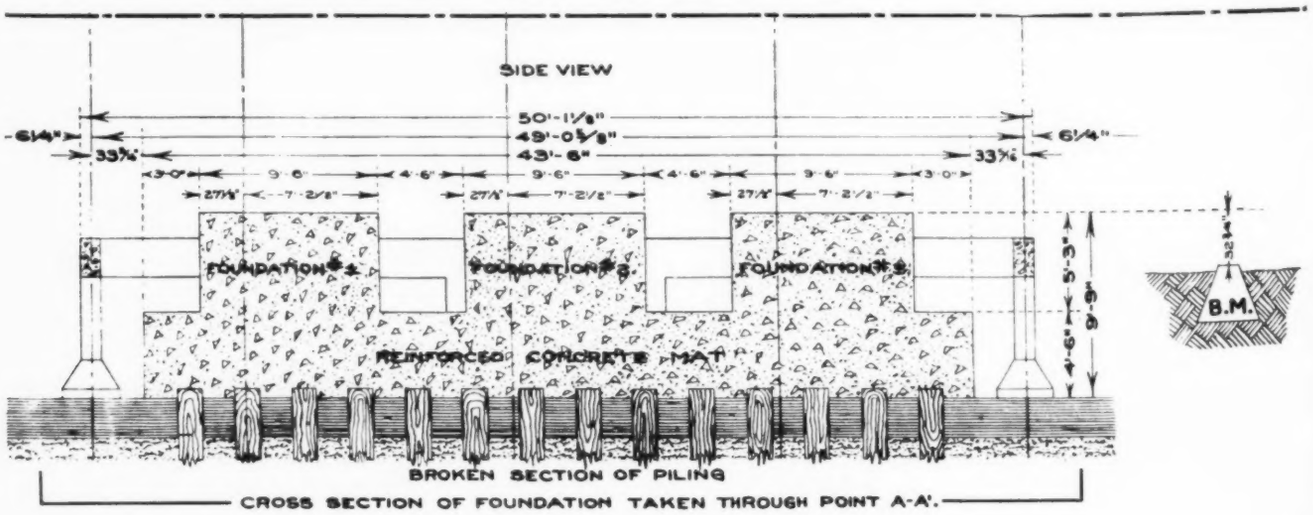
Large twin tandem engines require less weight in their foundations than any other class in the horizontal type. From .3 to .4 cubic yards per b. h. p. is sufficient, if properly distributed, while in large and medium sized single tandems from .4 to .5 cubic yards is necessary to obtain the same stability. Horizontal, single-cylinder engines (without outboard bearings) require from .5 to .6 cubic yards per b. h. p. Twin engines of the same type, however, demand less weight than the single cylinder engines by about ten per cent.

From .4 to .5 cubic yards of concrete per b. h. p. is necessary for single cylinder engines of the vertical type, and with multi-cylinder vertical engines the foundation weight can be reduced to .3 or .35 cubic yards per b. h. p.

These foundation weights will vary somewhat with the weight and speed of the engine. They are also based on normal soil strength.

During the summer of 1929 the writer was called upon to do some very interesting work for the Consolidated Gas Utilities Co. in connection with the design and construction of a gas compressing station where soil conditions were extremely unfavorable. The logical location for this station was near the northwest corner of the city of Wichita, Kansas. By making soundings and sinking a number of test holes, it was found that the top soil consisted of about four feet of sandy loam, and immediately below this, approximately eighteen inches of soft clay. Directly underlying the clay was found a fifteen-foot bed of quicksand and beneath it, a fine water-bearing sand. Coarse gravel was encountered after penetrating about twenty feet of the fine sand and hard pan at a total depth of forty-four feet.

The bearing strength of the quicksand, in place, was found



OF GAS ENGINE FOUNDATIONS

Consolidated Gas Utilities Co.

to be only about one thousand pounds per square foot, and after slight agitation this strength was reduced about twenty-five per cent. The bearing power of the eighteen-inch clay strata immediately above the quicksand indicated a strength of approximately 1,600 pounds per square foot.

On account of the quicksand underlying the top soil and in such close proximity to the surface, the matter of determining the type of engines to be used required the most serious consideration. With all horizontal engines the safety factor was found to be very slight, and in some cases a minus quantity, even with a concrete slab or mat underlying the entire installation. By installing multi-cylinder vertical engines the factor of safety could be increased somewhat, but not sufficiently to warrant this installation.

It was determined, therefore, that regardless of what type engines were used in the installation, piling would be required, to be driven through the upper formations and into the hard pan. For this, fifty-foot wood piling were obtained, to be driven on three-foot centers each way.

First the surface soil was excavated down to the top of the clay. A steam hammer was procured and the first piling were driven on six-foot centers. With these first piling full penetration was obtained. However, when the pile driver was moved back to fill in the intervening spaces the lower formations had "tightened up" until in many cases it was impossible to get a penetration of more than thirty or forty feet.

The tops of the piling were then cut off to a general level about one foot above the soil. Heavy reinforcing steel was crossed on the tops of these piling. The engine forms were put into place, being supported temporarily with wooden trestles, where they were lined and leveled. After being securely braced, concrete piers were run under each form in sufficient number to give full support to the forms. After this concrete had set, the wood trestle work was removed and the engine forms rechecked for level and alignment. Reinforcing rods had been put through the forms of the supporting piers, which protruded sufficiently to give bond between the piers and main foundation.

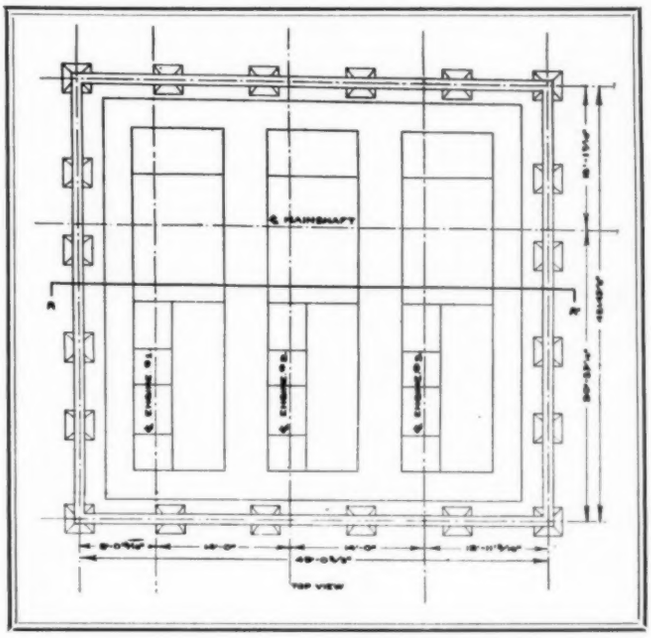
On all four sides a form four feet six inches high was built to confine the mat or slab which was to be run over the tops of the piling and which was to support the engine foundations. Further reinforcing steel was placed and the entire foundation was run monolithic.

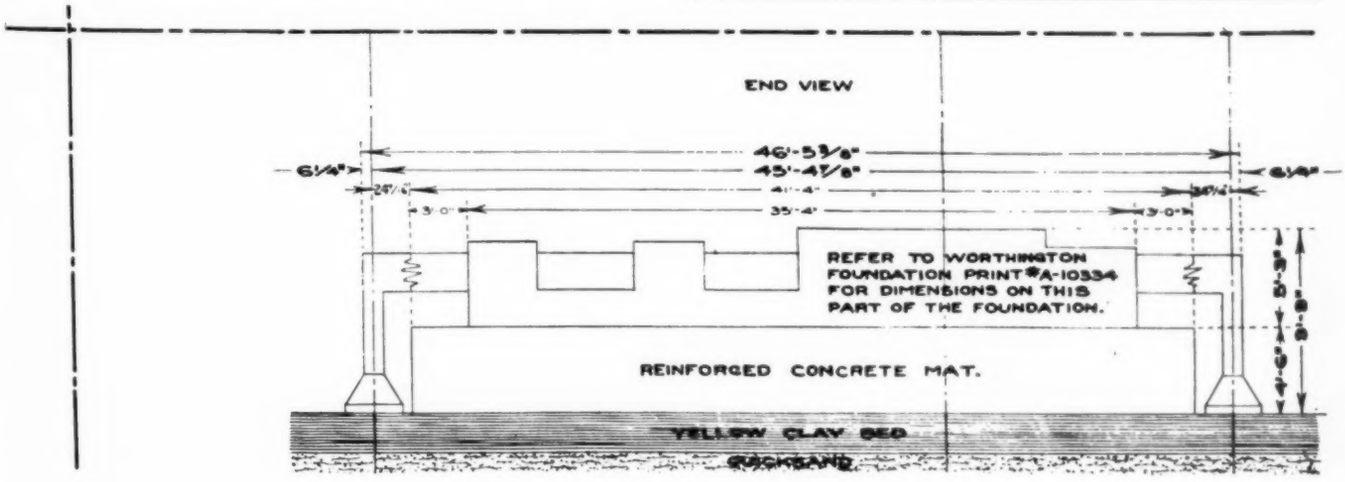
The concrete, which consisted of a one-three-five mixture, was mixed at the plant location and delivered immediately to the forms. Mixing and placing was continued without interruption until completed.

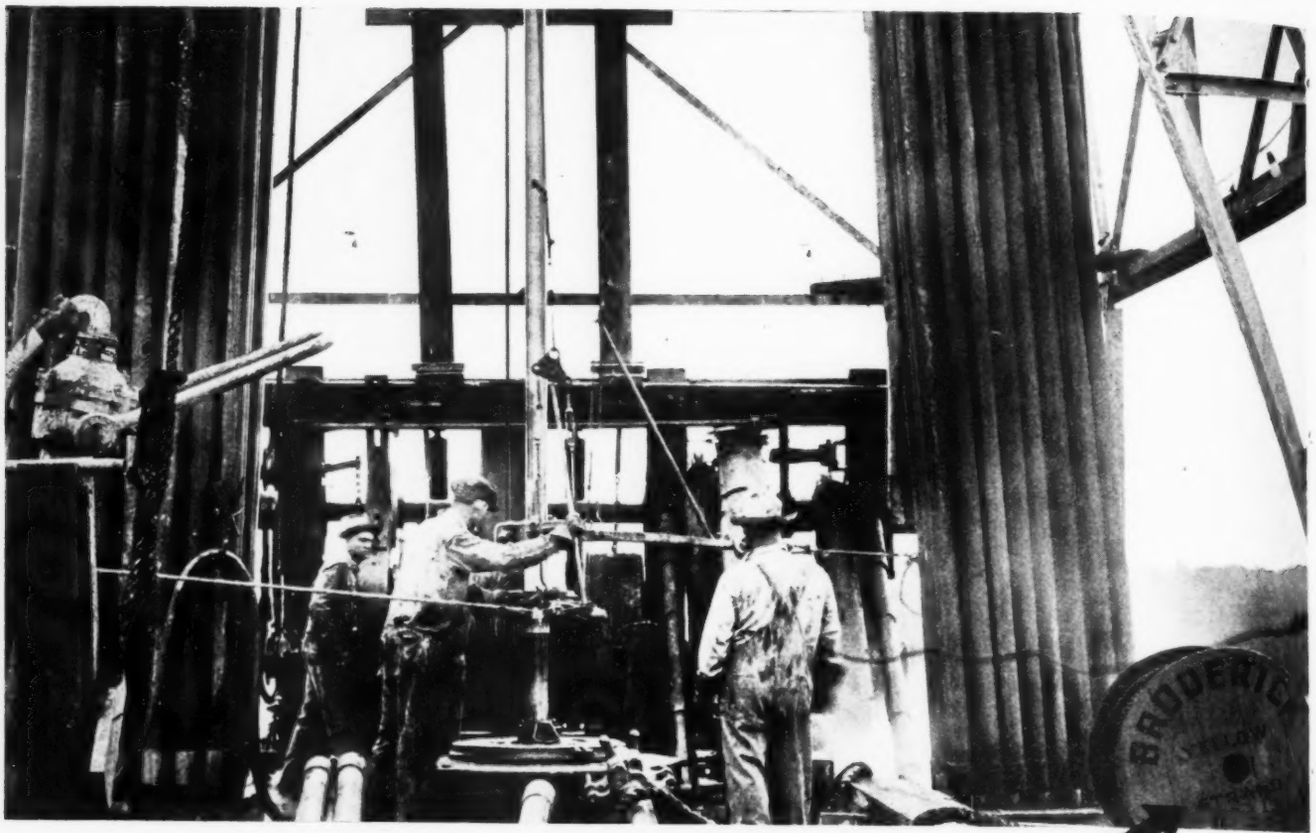
A separate and independent foundation was provided for the building. This consisted of a reinforced beam 12 inches wide by 24 inches deep, and supported by columns 12 by 18 inches on ten-foot centers, and with sufficient footings to insure ample bearing, even though these footings rested only a few inches above the top of the quicksand. This separate support was provided to prevent the vibration from the engines being transmitted directly to the building.

The writer acknowledges valuable assistance in this work from Messrs. D. K. Hutchcraft of Clark Brothers Company, J. A. Lupher with the Worthington Pump & Machinery Company, Forrest E. Gilmore, Engineer, and J. H. Biddison, Superintendent of Compressor Stations for the Consolidated Gas Utilities Co.

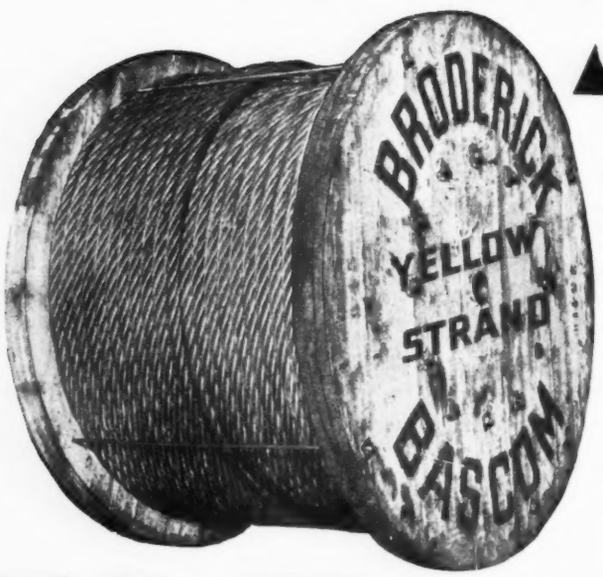
The successful operation of this station during the past season, with very slight vibration, indicates that the installation was entirely successful.







Off with the Old—
On with the New!



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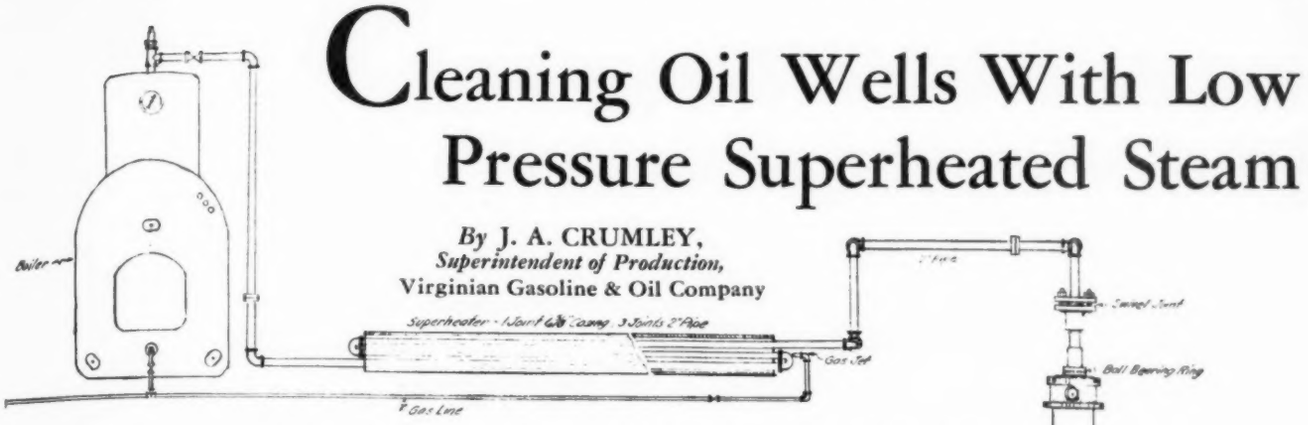

AT times we have to tear a leaf from the old-timers' book of experience to serve a present-day need, and the steaming of oil wells to remove paraffin presents such a case. The old method was to steam the oil sand either through the tubing or to run a string of ¾-inch steam line down alongside of the tubing to the oil sand. By this process the well was steamed without pulling the rods and tubing.

When the hole had cooled after steaming, the water, oil and thin paraffin were pumped out. These operations were repeated from time to time until the hole was clean. (Note: The traveling valve was pulled out of the working barrel in order that the valve cups would not be burned off while the well was steamed.) This method worked successfully on wells up to 1,000 feet in depth. In most wells drilled deeper than 1,000 feet the steam condensed and only warm water reached the bottom of the well. The warm water caused the paraffin to run, plastering up the oil sand and shutting off practically all the oil.

Having tried the old method several times and observing other operators use it with no results, the writer thought there must be some way to force live steam to the bottom of a 2,000-foot hole. This was accomplished in the following manner:

An eight-foot length of two-inch pipe (see detail illustrated) was placed on the tubing. The expansion of the casing and tubing when heat is applied must be figured in order to keep the perforation opposite that portion of the sand to be steamed.

The tubing was hung on a ball-bearing ring and connected to the steam line by a swivel joint. This will permit the tubing to be rotated from time to time so the live steam under pressure is brought in contact with all of the sand. The small-diameter hole in the perforated pipe keeps the pressure of the steam at the bottom of the hole at nearly boiler pressure. The steam escapes through the hole at sufficient pressure to cut and wash the paraffin and loose sand to the bottom of the hole, leaving a clean surface on the sand. The boiler was placed 50 feet from the well and a superheater placed between the boiler and the well. (See illustration.)

A pressure of 125 pounds was carried on the boiler. The stop cock was opened wide so the steam would not expand and condense before reaching the bottom of the hole. The well which was steamed is 16 years old. The initial production was 350 barrels per day. It was cleaned out and steam applied for 76 hours; twenty hours after the steam was shut off the sand pump was run. The water at the bottom of the hole was so hot that it burned the leather of the sand pump valve. A bailer was run and two barrels of paraffin and two and one-half barrels of water were removed from the well. It was found that the sand remained hot seven days. In measuring up the hole after steaming it was found to have filled up with sand caving to within three feet of top of shot hole. In the past this well had been shot and cleaned out several times, but with very little results, and the sand did not cave very much after each shot.

The sand cavings (after shot) were black and dirty with paraffin, but after steaming the sand removed from the hole was white and clean. This shows that all the paraffin was melted off the sand.

The water temperature in the hole before steaming was 57 degrees F. Twenty-one hours after the steam was shut off the temperature was 198 degrees F.

The temperature of the water taken from the well during seven days is given below:

November	30, 1928	198°
December	1, 1928	183°
December	2, 1928	165°
December	3, 1928	148°
December	4, 1928	129°
December	5, 1928	108°
December	6, 1928	87°

The production before and after steaming and cleaning out follows:

	Barrels Per Week	
Nov. 21, 1928	5	Before steaming.
Feb. 7, 1929	5	After steaming.
Feb. 14, 1929	11	
Feb. 21, 1929	12	
Feb. 28, 1929	10	
Mar. 7, 1929	11	
Mar. 14, 1929	12	
Mar. 21, 1929	12	
Mar. 28, 1929	9	Showing some water.
Mar. 31, 1929	4	5 Barrels of water.
Apr. 7, 1929	9	35 Barrels of water.
Apr. 14, 1929	15	4 Barrels of water
Apr. 21, 1929	16	No water.
Apr. 28, 1929	18	No water.
Apr. 28, 1930	24	No water.

By using this method of low pressure superheated steam, only the average well equipment found on the lease is needed.

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